



# The American Journal of Surgery

Editor: THURSTON SCOTT WELTON, M.D., F.A.C.S.

Editor, Department of Radiology: JAMES T. CASE, M.D., F.A.C.S.

*this Issue 206 Text Pages*

## NEWER ANESTHETICS 18 ARTICLES

SIX OTHER ARTICLES

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BIOGRAPHICAL BREVITIES • BOOK REVIEWS

BOOKSHELF BROWSING

Livingston's—A Clinical Study of the Abdominal  
Cavity and Peritoneum, Part Seven

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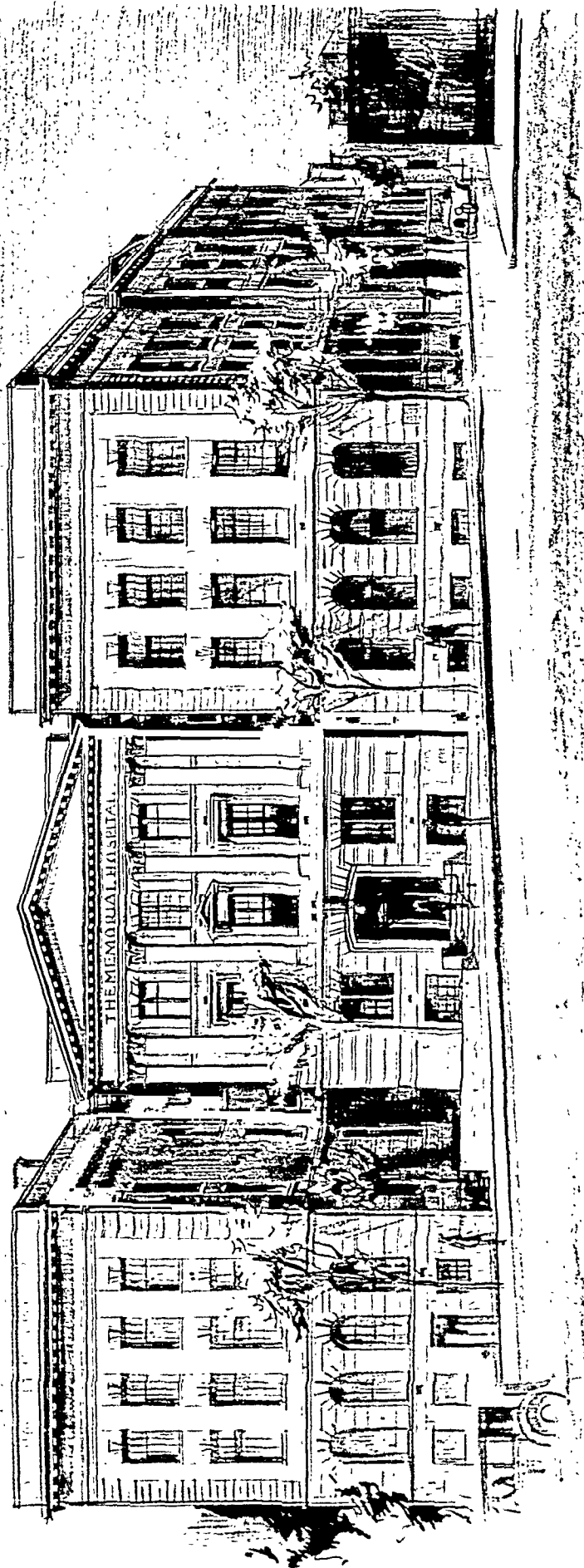
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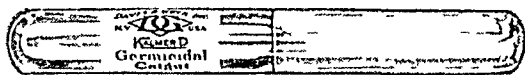
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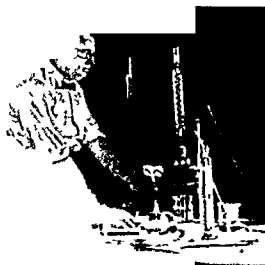


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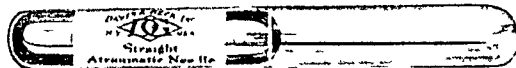
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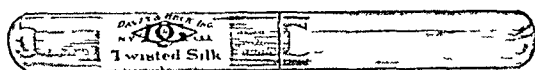


NO.	INCHES IN TUBE	SIZES
350..CELLULOID-LINEN.....	60.....	000, 00, 0
360..HORSEHAIR.....	168.....	00
390..WHITE SILKWORM GUT..	84.....	00, 0, 1
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450..WHITE TWISTED SILK...60.....	000 TO 3	
460..BLACK TWISTED SILK....60.....	000, 0, 2	
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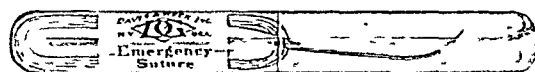
NO.	INCHES IN TUBE	SIZES
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812..10-DAY KALMERID “	..20..00, 0, 1, 2, 3	
822..20-DAY KALMERID “	..20..00, 0, 1, 2, 3	
862..HORSEHAIR .....	56.....	00
872..WHITE SILKWORM GUT...28.....	.....	0
882..WHITE TWISTED SILK....20.....	000, 0, 2	
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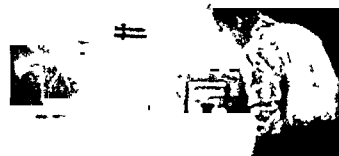


NO.	INCHES IN TUBE	SIZES
904..PLAIN KALMERID CATGUT..	20..00, 0, 1, 2, 3	
914..10-DAY KALMERID “	..20..00, 0, 1, 2, 3	
924..20-DAY KALMERID “	..20..00, 0, 1, 2, 3	
964..HORSEHAIR.....	56.....	00
974..WHITE SILKWORM GUT...28.....	.....	0
984..WHITE TWISTED SILK....20.....	000, 0, 2	

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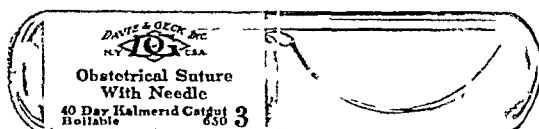
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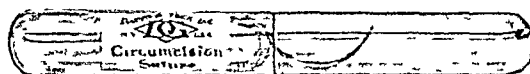
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000	_____	4	_____
00	_____	6	_____
0	_____	8	_____
1	_____	8	_____
2	_____	16	_____
3	_____	24	_____

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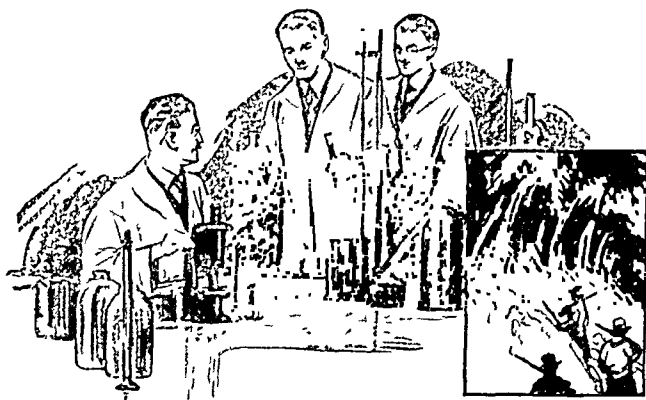
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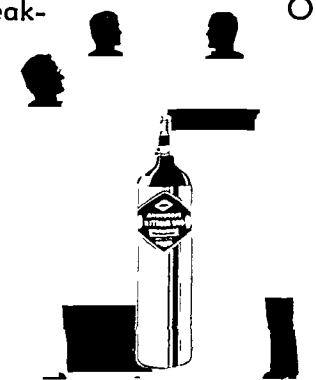
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## GENERAL INFORMATION

Original articles are published only with the understanding that they are contributed exclusively to this Journal. Manuscripts offered for publication, correspondence relating to the editorial management and books for review should be sent to The Editor, THE AMERICAN JOURNAL OF SURGERY, 76 Fifth Avenue, New York, N. Y.

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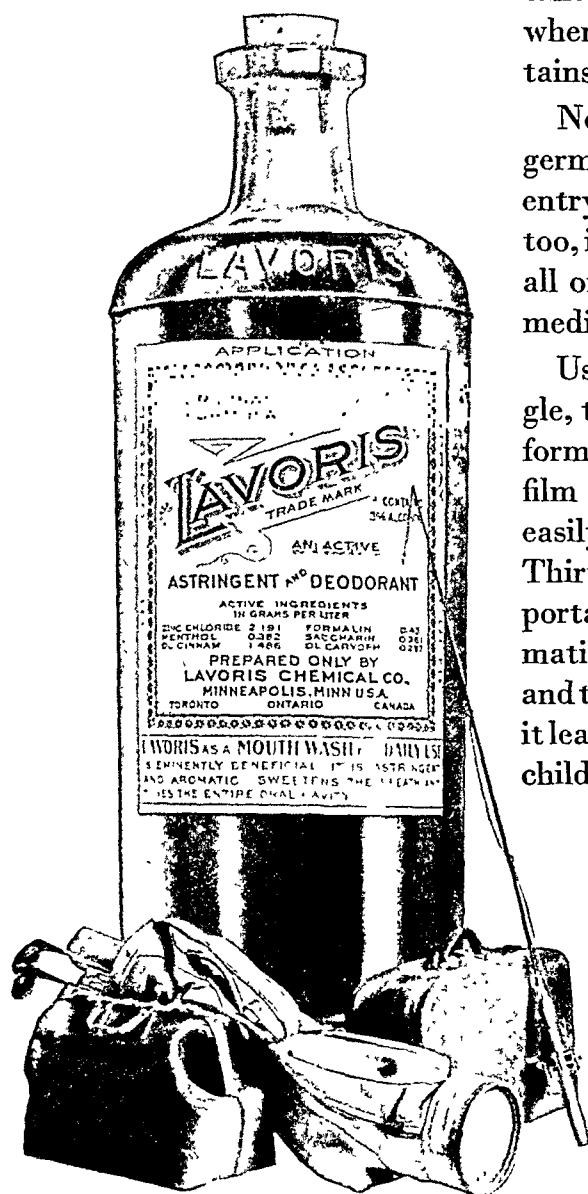
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No. 1

## PRELIMINARY REPORT ON A NEW LOCAL ANESTHETIC (NUPERCAIN)\*

EDWARD L. KEYES, M.D., AND ALLISTER M. McLELLAN, M.D.

NEW YORK

**N**UPERCAIN is a new local anesthetic that has been used (under the name of percain) in Europe and praised because the resulting anesthesia persists for six or eight hours.

Miescher<sup>1</sup> of Basle, working with the quinine nucleus, has synthesized this new substance which is alpha-butyloxycinchonic acid diethyl-ethylen-diamide hydrochloride.

*Physical Properties:* Nupercain is in the form of colorless crystals, is neutral in reaction, readily soluble in water and may be repeatedly boiled. If a solution is rendered alkaline, the drug precipitates as a free base; hence it must be used in a slightly acid solution and kept in alkaline free containers. The drug, as we have used it, is actually dispensed in ampules dissolved in physiological saline solution acidified by one drop of concentrated hydrochloric acid per liter of solution.†

*Toxicity:* Uhlman<sup>1</sup> has studied the drug pharmacologically and reports it five times as toxic as cocaine when injected subcutaneously into rabbits and guinea pigs; Lipschitz and Laubender<sup>2</sup> find it twice as toxic as cocaine when injected intravenously into rabbits; and Gray,<sup>3</sup> using it subcutaneously in dogs, finds it twice as toxic as cocaine. Uhlman also reports that the greater the concentration the greater the

toxicity. Freund<sup>4</sup> has reported 1 death following subcutaneous injection of 130 c.c. of 1:1000 solution. Heckenbach<sup>5</sup> has reported 1 death following a paravertebral anesthesia. The post-mortem examination confirmed the presumption that the injection had been made inadvertently into the spinal canal where the prick of the needle was distinctly visible. Siebner<sup>10</sup> reports the death of a patient with hyperthyroid disease after the injection of 90 c.c. of 1:1000 solution. The death was not attributed to nupercain but he has reduced the amount used in later thyroidectomies.

Patients recovered from 750 and 1500 mg. given inadvertently. The former was not sick; the latter was severely poisoned.

The following unpublished deaths are a warning of the toxicity of nupercain:

1. Cesarean section. Three hundred and eighty milligrams of nupercain in 1:1000 solution injected subcutaneously. Twenty minutes after injection, vomiting, convulsions, cyanosis, tachycardia, death. Autopsy revealed severe pyelonephritis with abscesses in right kidney. Death was ascribed to the renal condition.

2. Through mistake a 1 per cent solution was used instead of 1:2000. Total dose not stated. Death resulted, autopsy revealing hyperthyroidism and status lymphaticus.

3. Through mistake a 10 per cent solution was injected. Death occurred ten minutes after an unstated dose.

4. Eighty cubic centimeters of 1 per cent

† It is readily adsorbed by filter paper. Therefore if filtered the first 10 per cent of the filtrate must be discarded.

\* Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, February 19, 1930.



solution (800 mg.) was injected by mistake. Death was almost immediate.

5. An unstated amount of 1 per cent solution was injected into the bladder. Death occurred in ten minutes.

This toxicity is compensated for by the fact that nupercain is 10 times as anesthetic as cocaine, may be used in a very diluted solution and produces a more enduring anesthesia.

*Clinical Reports:* Christ,<sup>6</sup> Hofer,<sup>7</sup> Ritter<sup>8</sup> and Von Seeman<sup>9</sup> reporting 500, 300, 309 and 400 cases of infiltration anesthesia respectively, have all reached the same conclusions as regards non-irritability locally, absence of susceptibility and prolonged anesthesia lasting an average of six to eight hours. Christ reports that one-fifth of his cases did not have postoperative pain. Local vascular dilatation is like that of procaine and controllable with adrenalin (10 drops to each 100 c.c. of solution).

Christ prefers 1:1000 solution of nupercain (the other three 1:2000) to which is added 5 drops of dilute hydrochloric acid per liter and recommends as maximum doses for local infiltration, 400 c.c. of 1:2000 solution, 150 c.c. of 1:1000 solution or 50 c.c. of 1:500 solution.

Heckenbach<sup>5</sup> used as his maximum dose 400 c.c. of 1:2000 solution, Von Seeman<sup>9</sup> 350 c.c. of 1:2000 or 200 c.c. of 1:1000 and Siebner<sup>10</sup> 200 c.c. of 1:1000 with an additional 100 c.c. of 1:2000.

Spinal anesthesia has been reported by Ziegner<sup>11</sup> on 52 cases. He uses a 1 per cent solution, finds 10 mg. too much and is now using 8 mg. No permanent injuries were noted. The duration of the anesthesia is from three to ten hours. Christ<sup>6</sup> used 4 c.c. of 1:1000 solution in a few cases.

Caudal anesthesia with 30 c.c. of 1:500 solution has been recommended by Heckenbach.<sup>5</sup>

Mucous membrane (urethra and bladder) anesthesia has been entirely satisfactory, especially long persisting and without accident in 1:1000 solution to which is added 10 to 15 drops of adrenalin

(1000 cases as reported by Heckenbach<sup>5</sup>). Siebner<sup>10</sup> also recommends 1:1000 solution. (Uhlman<sup>1</sup> reports nupercain ten times more anesthetic than cocaine on the rabbit's cornea.)

#### PERSONAL EXPERIENCE

This paper is founded on the use of nupercain for caudal (59 cases), spinal (46 cases), local and surface (urethral) anesthesia. In no instance has adrenalin been added to the solution.

#### CAUDAL ANESTHESIA

Thirty cubic centimeters of a 1:1000 solution of nupercain are injected into the *sacral canal*.\*

This anesthesia has been employed 59 times, 40 times in the office for cystoscopic fulguration of bladder tumors or ulcers (11 cases), observation and pyelogram (13 cases), tuberculosis of bladder (2 cases), urethral caruncle (2 cases), litholapaxy (oxalate stone 2.5 cm. in diameter), urethroscopic treatments (9 cases) and curetting perineal urinary sinus (2 cases); in the hospital for observation and pyelogram (12 cases), cystoscopic fulguration of bladder tumors (1 case), fulguration of bladder ulcer (2 cases), tuberculosis of bladder (1 case), punch operation (1 case), dilatation of urethral stricture (1 case) and removal of perineal packing (1 case).

Anesthesia has been satisfactory except in 5 cases (3 of these were given by the hospital interns, the only ones they gave).

Two patients had previously exhibited a susceptibility to procaine.

**CASE 1.** Male, fifty-six years old. Office cystoscopic treatments for bladder tumor six times during 1928. The patient was on digitalis, an extra dose of which he took before each treatment. Extremely apprehensive. Caudal anesthesia by 30 c.c. of 2 per cent procaine each time. Before the whole dose had been given he would always complain of palpitation, dizziness and tinnitus which increased from from five to ten minutes, the pulse becoming irregular and rapid (140-150).

\* Twice 35 c.c. of 1:1000 solution and twice 25 c.c. of 1:2000 solution were used.

On November 12, 1929, cystoscopic examination under nupercain caudal anesthesia. No reaction subjectively or objectively. No tumor seen.

CASE II. Male, fifty-five years old. Office cystoscopic treatments for bladder tumor under procaine caudal anesthesia (30 c.c. of 2 per cent solution); eight in 1927-28-29. On October 21, 1929, nupercain caudal anesthesia was given but the patient was not informed of the change as it was suspected that the reaction was partly psychic. The following note was made: "He has had eight caudal anesthetics of procaine (30 c.c. of a 2 per cent solution). Each time he had a reaction which occurred after the first 5 to 10 c.c. had been injected. There would be mild delirium; he might not recall what had happened. However, little change was noted in the pulse rate or blood pressure during this period, so the whole amount was injected. He would be clear mentally in from ten to fifteen minutes. Today caudal anesthesia of nupercain was injected quickly and there was no reaction. Tumor fulgurated."

Caudal anesthesia under nupercain was repeated December 4, 1929. No reaction and no tumor seen.

One case seems to have shown personal susceptibility to nupercain.

CASE III. Male, fifty-seven years old. During 1928-29 he was given thirteen caudal anesthetics of 30 c.c. of 2 per cent procaine for cystoscopic fulguration of bladder and urethral tumors. He had slight dizziness and a congested feeling in the nose each time. On November 20, 1929, he was given a caudal anesthesia of nupercain (30 c.c. of 1:1000 solution) and was informed of the change. He had the same symptoms as with procaine except that the dizziness was more intense and prolonged. He prefers procaine.

*The onset of anesthesia* is said to be somewhat delayed as compared to procaine. Thus a dentist to whom we gave some nupercain found that anesthesia of a tooth might be delayed as long as thirty minutes, which was interpreted as slow conduction through bone. We have not noted this delay.

*Duration of the anesthesia*, as determined from the patient's first discomfort, e.g.,

burning on urination, etc., occurred in from one to eight hours after injection, an average of five hours (30 cases). One excellent anesthesia was the litholapaxy, which was done in the office, upon a patient who was suffering from incontinence of urine due to imperative urination. The procedure was painless. He returned to the office eight hours later, having slept most of the afternoon, and passed 5 oz. of urine without discomfort. Next morning his urine was free from blood. He remained well.

Five patients had no pain whatever following cystoscopy. Two had pain when a meatotomy was performed although simultaneous cystoscopy was painless. Fulguration of an ulcer was painless except when the bladder was distended to over 120 c.c. (This ulcer was later resected under nupercain spinal anesthesia. No pain was felt during abdominal section but the bladder sensibility to distension remained so acute that ether had to be used.)

*The one disadvantage* to using nupercain caudal anesthesia in the office is the temporary paralysis that may ensue. Twice this delayed the patient's departure.

CASE IV. Male, thirty-one years old, using crutches because of almost complete paralysis (infantile) of the leg muscles. On November 8, 1929, under nupercain caudal anesthesia (30 c.c. of 1:1000 solution) he was urethroscoped for diagnosis. The anesthesia was perfect. On account of the paralysis of the legs he was carried from the table to a couch, but was able to leave in two and one-half hours.

CASE V. Male, thirty-seven years old. On December 2, 1929, under nupercain caudal anesthesia (30 c.c. of 1:1000) a pyelogram was made. This patient had to be assisted from the table and was delayed in the office two and one-half hours.

The possibility of retention of urine following caudal anesthesia with nupercain should be borne in mind. One patient passed air twenty hours after the anesthesia, which means he had some retention during that time.

## SPINAL ANESTHESIA

Spinal anesthesia has been employed in 46 cases. Ten grains of veronal\* were given the night before and repeated one hour before the operation. Fifty milligrams of ephedrine sulphate were given orally when the patient left the bed for the operating room. Ampules of procaine containing ephedrine sulphate (50 milligrams) were used to anesthetize the interspace. Thus the patient received in all 100 milligrams of ephedrine.

The injection may be made in the sitting position provided the patient lies down immediately thereafter.

The solution employed by us at first was 1:1000. As no toxic symptoms ensued, we have gradually increased the concentration in successive cases† and are now injecting 2 c.c. of a 1:200 solution. No intoxication or paralysis has been observed. There has been one spinal headache.

The height to which the anesthesia reaches depends on the interspace used, the degree of dilution with spinal fluid, the amount of anesthetic injected and the amount of spinal fluid withdrawn.

There were 24 suprapubic bladder operations: prostatectomies (9 cases‡), prevesical section and bilateral ligation of the vasa deferentia (11 cases), fulguration of bladder tumor (2 cases), resection of bladder ulcer (1 case), closure of fistula (1 case).

There were 9 kidney operations: 2 pyelotomies for stone (one a very bad risk, the other including a division of ureteral stricture), 1 heminephrectomy for a supernumerary ureter which opened into the urethra; 3 nephrectomies, 1 exploration of the loin (disclosing perisplenic suppuration and absence of kidney), 1 perinephritic abscess and 1 nephropexy.

\*Recently we have employed scopolamine (grains  $\frac{1}{200}$ ) and morphine (grain  $\frac{1}{4}$ ) preliminary anesthesia and have eliminated one of the 50 mg. ephedrin doses.

†Six patients received 5 c.c. of 1:1000 solution, 4 received 2.5 c.c. of 1:500, 6 received 1.5 to 2.75 c.c. of 1:250, 2 received 1.5 c.c. of 1:200 and the others received 2 c.c. of 1:200.

‡One plus diathermy for tumor of bladder; one plus diverticulectomy.

A patient with renal colic following a cystoscopic examination elsewhere was given a spinal injection of 5 c.c. of 1:1000 solution. The pain stopped in five minutes but returned in two hours; a second patient with renal colic was given 1 c.c. of 1:200 and this was ineffective. (Attention is called to spinal anesthesia as a method of relieving renal colic.)

There were 11 urethral and intravesical operations: external urethrotomy (2 cases 1 with extensive periurethral gangrene), litholapaxy (2 cases), fulguration of bladder tumor (2 cases), "punch" operation (4 cases), resection of a tuberculous perineal sinus (1 case).

The anesthetic was perfect 36 times (2 patients towards the end of the operation complained of a dull ache but no supplemental anesthetic was necessary). Three (2 renal and 1 vesical) were given ether on complaint of pushing or pulling sensation. Seven were given supplementary anesthesia for pain. One of these patients, after the bladder had been exposed suprapubically, complained of pain when the bladder was distended. Another (this was the second case in which nupercain was used) had only parasthesia of his legs so he was given a spinal injection of procaine crystals (120 mg.) which gave perfect anesthesia. A third patient had a large bladder tumor removed and the base fulgurated and the bladder closed about a drainage tube; then the peritoneum was opened for prognostic purpose and, as the peritoneum was sensitive, ether was given. The fourth was the patient having perisplenitis. She had pain as the diaphragm was pulled upon. The fifth and six, both kidney cases, required nupercain 1:1000 in the upper angle of the wound. The seventh, a prostatectomy, had anesthesia only of the legs due to faulty technic.\*

\*One of us (K) has noted that since he no longer uses novocaine, a chronic eczema of the fingers of five years' duration has disappeared.

We have further learned that for mucous membrane anesthesia, a 1:250 solution is more effective than any local anesthesia, we have previously employed.

Recently we have twice repeated spinal injection because the anesthesia was inadequate.

During the operation there were no alarming symptoms. Variations in pulse and respirations could readily be attributed to the operation. Vomiting during the operation did not occur. (Only 3 patients vomited thereafter, one of them but once.)

The systolic blood pressure of 29 patients fell an average of 18 points; that of 11 others did not fall. The maximum fall was 70 points.

The duration of the anesthesia varied from one and a half to twelve hours.

The average duration was between seven and eight hours. Nine patients did not complain of any postoperative pain, but all open operations required sedatives the following night.

One patient (prevesical section and ligation of the vasa deferentia) had a slight ache in the wound during the operation. This persisted and required codeine seven hours later.

CASE VI. One patient, a man seventy-three years old, had a cystotomy for drainage and removal of a large phosphatic stone from a diverticulum ten days previously. He was given 11 mg. of nupercain in a 1:250 solution. Two large diverticula of the bladder were removed in two and one-half hours. Two hours and forty minutes after the spinal anesthesia had been given, a very large adenomatous prostate was removed without pain. The patient was in poor condition and lost much blood. He was given a blood transfusion before he was returned to his bed. He felt no pain and made an uneventful recovery.

CASE VII. A woman, fifty-six years old, for years had suffered from symptoms characteristic of ulcer of the duodenum. Her gastrointestinal x-ray series showed a defect characteristic of ulcer. She developed a fever with pain and rigidity in the left loin, quite high up. She was given a spinal anesthetic of nupercain and cystoscoped. The right kidney seemed to be functioning normally; the left ureteral orifice could not be found even with the aid of indigo carmine. She was accordingly removed to the operating room and one hour

and forty minutes after anesthetization, the left loin was opened and explored. A kidney could not be found but when the exploration was extended up under the diaphragm, the peritoneum was opened, the spleen found small and adherent and further investigation revealed a retroperitoneal caking of the fat behind and beyond the spleen. Manipulation at this point (about two hours after anesthetization) was painful, so general anesthesia was given while the infiltrated area was explored to a depth of about 5 cm. No gross suppuration was disclosed. There was considerable venous oozing and the distance from the superficial wound to the point of exploration was so great that it seemed wise to discontinue the search. The oozing point was packed, general anesthesia discontinued. The suturing excited no pain. The sensitiveness in this case was interpreted as being a technical defect in that the anesthesia had not been carried high enough. Indeed had the exploration extended no further than the kidney, the anesthesia would doubtless have been entirely successful. Operation was completed with the patient awake and not complaining of pain. Recovery uneventful. Symptoms relieved.

#### A STUDY OF THE FALL IN BLOOD PRESSURE FOLLOWING SPINAL ANESTHESIA

For the past three years we have kept a record of the blood pressures of patients who submitted to spinal anesthesia. The technic has been the following:

The patient's blood pressure is taken. Ephedrine is then administered and the blood pressure taken again. The spinal anesthetic is then given and thereafter the blood pressure is taken every five minutes for thirty minutes, then every fifteen minutes until the pressure begins to return definitely toward normal, if it has not already done so during the half hour.

During these years we have employed three anesthetics; first procaine crystals (usually 120 mg.), then the mixture called spinocaine (usually 200 mg. of procaine) and finally nupercain. We have thus obtained quite complete blood pressure records on 43 procaine spinal anesthetics, 54 spinocaine anesthetics and 41 nupercain anesthetics.

A detailed statistical study of the blood pressure readings would have little value, for these are influenced by a number of imponderable factors such as arteriosclerosis, operative shock, loss of blood and most of all the patient's apprehension. Thus 10 patients were twice given spinal anesthesia with the same solution and as far as possible under the same conditions. The second anesthesia was no more disturbing than the first, but the blood pressure curves never matched any more closely than might those of 2 unrelated patients.

Yet every effort was made to make the technic comparable. One hundred milligrams of ephedrine were administered before operation when procaine or nupercain was used; 50 mg. when spinocaine was used. During operation the patient's head and shoulders were lowered about 15° below the hips. In order to lessen the patient's emotional reaction, morphine or veronal was employed. We cannot say that one of these was more effective than the other.

But in view of the dissimilarity in chemical composition between procaine and nupercain, it has seemed worthwhile to attempt a comparison of the blood pressure curves with reference to 2 points: (1), the total fall in blood pressure, and (2) the curve of blood pressure.

The average maximum fall of blood pressure after procaine was 31 mm., after spinocaine (perhaps because less ephedrine was used) 39 mm., after nupercain 18 mm. For a few patients the vasoconstrictor effect of the ephedrine was never overcome by the vasodilatation of the spinal anesthesia. Such patients had at all times after the ephedrine was administered a blood pressure higher than before. Our nupercaine series shows 11 such cases (25 per cent), the procaine series 4 (9 per cent), the spinocaine series 3 (6 per cent).

There is a marked difference in the curve of blood pressures after nupercain as compared with procaine and spinocaine. When the blood pressure drops little if at all, this distinction does not appear. When the

whole series is plotted the nupercain series shows almost a straight line, the 2 procaine series a gradual decline with its lowest point at the end of the half hour. But in individual cases the difference in the curve shows clearly and may be depicted by a curve of those cases that were the least influenced by ephedrine. We have arbitrarily chosen a drop in blood pressure of at least 20 mm. or more as representative.

Eleven nupercain cases dropped 20 points or more. The drop was almost immediate, within the first five minutes. The lowest point was reached in twenty-five minutes and between thirty and forty-five minutes after the spinal injection had been given the blood pressure had returned to where it stood five minutes after the anesthetic had been injected. The subjoined table shows the fall of blood pressure measured in millimeters of mercury at five-minute intervals after nupercain (11 cases), procaine (23 cases) and spinocaine (27 cases).

Minutes.....	5	10	15	20	25	30	45
Nupercain.....	19	20	23	23	29	22	17
Procaine.....	7	7	21	20	31	31	17
Spinocaine.....	9	15	24	29	31	38	27

It has been extremely reassuring to find that the blood pressure begins to return to normal as soon after nupercain as it does after procaine and to be reassured that an initial sharp drop in blood pressure after nupercain does not usually imply a further drop of 30 to 50 points as would be the case after procaine.

#### LOCAL ANESTHESIA

Local anesthesia (1:1000 solution) was employed in a few cases, cystotomy, circumcision, urethral caruncle, meatotomy and incision of abscess. It was efficient.

One of us has had 3 teeth extracted under nupercain (1:1000 solution) anesthesia. The anesthesia was perfect. Twelve hours later on retiring there was no pain. The next morning one side was sore but on the other side there never was pain.

A patient with bilateral hydrocele was anesthetized with procaine on the right side, with nupercain on the left. The right side was sore ninety minutes later; the left side did not become sore.

The maximum dose used by us was 60 c.c. of 1:1000 solution.

#### SURFACE (URETHRAL) ANESTHESIA

Five cubic centimeters of a 1:500 solution is injected into the anterior urethra and held in for three minutes. Then an additional 10 to 15 c.c. are gently forced into the posterior urethra and bladder. This has been entirely satisfactory for the gentle passage of instruments through a sensitive urethra. A 1:200 solution in 1 case controlled the pain of a chancroid of the glans and prepuce.

#### CONCLUSIONS

1. Nupercain, in about ten times the dilution of cocaine, is an excellent local anesthetic.

2. The solution must be kept slightly acid.

3. It may be boiled. It may be used in conjunction with adrenalin or with procaine.

4. The minimal reported lethal dose for an adult human being is 90 mg. (90 c.c. of 1:1000 solution). Individuals have survived the administration of 750 and 1500 mg.

5. Several surgeons have recognized 200 c.c. of a 1:1000 solution as the maximum dose for local anesthesia. Our maximum dose has been 60 c.c.

6. We have usually given 30 c.c. of 1:1000 solution (30 mg.) for caudal anesthesia; 2 c.c. of 1:200 solution (10 mg.) for spinal anesthesia.

7. The failure of block anesthesia, whether caudal or spinal, may be attributed to an error of technic.

8. Nupercain is preferable to procaine for,

(a) Personal susceptibility to nupercain is negligible as compared to procaine, and

(b) The resultant anesthesia always lasts ninety minutes, and usually as long as six to eight hours.

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#### DISCUSSION

DR. JECK: I shall base my discussion on the following four methods of anesthesia in which we have employed nupercain:

1. Locally in the urethra.
2. As a caudal or epidural anesthetic.
3. As a local infiltration anesthetic.
4. As a spinal anesthetic.

1. For the past two months I have used nupercain locally in the urethra to a considerable extent. In general I have found it quite as satisfactory as the 10 per cent novocaine solution which I had previously employed. I have never seen any constitutional symptoms as a result of its use in this way.

2. Dr. McLellan has given for me a number of caudal or epidural nupercain anesthetics to alleviate the pain of cystoscopic examination and treatment. In each instance he used 30 c.c. of a 1:1000 solution. The anesthesia was very satisfactory in all cases. He recently anesthetized a patient of mine who is a doctor. The latter had a small papilloma in the vertex of his bladder and was extremely sensitive to cystoscopic manipulation. I burned the papilloma with the high frequency current, the entire job taking some thirty minutes. The doctor did not evince the slightest discomfort at any time during the procedure.

I think there is no doubt that the effects of nupercain as an epidural anesthetic are much more lasting than the effects of novocaine. I can recall several instances where I had given novocaine (30 c.c. of a 2 per cent solution) as a caudal anesthetic and while the anesthetic was perfect for fifteen or twenty minutes, after that time it wore off to such an extent that further cystoscopic manipulation was done with considerable difficulty and much discomfort to the patient.

3. I can relate only one personal experience with nupercain employed as a local infiltration anesthetic and that was in an operation for bilateral hydrocele. The operation was per-

formed on the Urological Service at Bellevue. Both hydroceles were quite large. On the right side I employed 25 c.c. of 1:1000 nupercain solution. On the left side 30 c.c. of  $\frac{1}{2}$  per cent solution of novocain were employed. While the right side was actually somewhat larger than the left, less of the nupercain solution was used than the novocaine which, however, was probably due only to the fact that our supply of nupercain was limited.

The anesthesia was very satisfactory on both sides. However, the patient did complain a little less on the suturing of the skin of the right side than he did when the same procedure was carried out on the left. Certainly in this one instance the nupercain worked every bit as well as novocaine ordinarily does, even when used in a 1 or 2 per cent solution.

4. As a spinal anesthetic I have observed the results in only 4 cases. These were likewise cases recently operated upon on the Bellevue Urological Service.

Dr. McLellan has called attention to the fact that in the majority of his spinal cases the blood pressure dropped rapidly from the start. As you will note in 3 of these cases, the blood pressures acted in quite the contrary manner, that is, they had a tendency to go higher. But this I attribute to a difference in technic in that on the Bellevue Service we are now giving 1 c.c. of ephedrine (50 mg.) at the time the skin is anesthetized for the introduction of the lumbar puncture needle. Then immediately after the anesthetic is injected into the spinal canal, another centimeter of ephedrine is given hypodermatically. In each case the blood pressure was taken before the first injection of ephedrine was given and the other blood pressure readings, recorded at five-minute intervals, were begun immediately after the patient was turned over on his back following the injection of the spinal anesthetic. The first case was a patient aged sixty-seven, on whom a prostatectomy (second stage) was done. His blood pressure before the anesthetic was given was 180/90. After the anesthetic was given the blood pressure readings were as follows: 190/80, 200/90, 210/90, 200/90, 200/90. The anesthesia was perfectly satisfactory and reached as high as the ninth rib in the mammillary line.

The anesthetic was injected at 2:25 P.M. The anesthesia, tested by means of pin pricks, was still good at 5:30 P.M. and at 6:30 P.M. there was a slight return of sensation in his leg.

The second case, aged sixty-three, represents another prostatectomy (second stage). When the patient was put on the table the blood pressure was 150/90. Immediately after the anesthetic was given the blood pressure dropped to 100/60 at which juncture 1 c.c. of ephedrine was given. Five minutes later the blood pressure was 100/50 and five minutes later 70/50. Here 12 minims of adrenalin were injected by hypo. Five minutes later the blood pressure was 70/50 and then at five-minute intervals 90/70 and 110/80.

The anesthetic was injected at 2:00 P.M. and at 5:30 anesthesia was still present. At 6:30 P.M. there was slight evidence of return of sensation.

The third case was merely a cystoscopic examination of a man aged fifty-seven. The first blood pressure was 120/90 and after the injection of nupercain, the blood pressure readings were as follows: 148/90, 148/90, 148/90, 150/90, 150/90, 150/90, 150/90. The anesthesia extended up to the eleventh rib in the mammillary line. It was given at 3:35 P.M. and was still present from the umbilicus down until 7:00 P.M. At 7:30 P.M. there was partial return of sensation.

The last case was a suprapubic prostatectomy. The first blood pressure was 115/60 and the blood pressure readings after the anesthetic was given were as follows: 120/70, 120/70, 118/65, 130/80, 138/80, 130/80, 130/80, 130/80, 130/80, 124/70, 120/70. The anesthetic was injected at 2:20 P.M. The anesthesia extended to the ninth rib. At 5:00 P.M. it was still present as high as the tenth rib and at 6:00 P.M. the highest point of the anesthetic was at the umbilicus. At 7:00 P.M. there was partial return of sensation.

In all of the cases the anesthesia was perfectly satisfactory and in no case were there any distressing or alarming symptoms whatsoever.

In closing I think it is only proper to call attention to Dr. McLellan's method of giving an epidural anesthesia which, to my mind, plays quite a part in the success of the procedure. Instead of using a long needle as many do, he employs a short needle, not over an inch long, and of small caliber. A needle of such length enables one to easily introduce the anesthetic just within the caudal canal which is apparently all that is necessary when a relatively large amount of solution is employed. It further obviates the danger of piercing the coverings of the spinal cord.

# SODIUM AMYTAL

## IN SURGICAL MANAGEMENT\*

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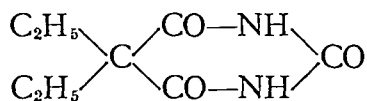
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THE recent use of sodium amytal, which is the trade name for sodium iso-amyl-ethyl-barbiturate, as an intravenous anesthetic has caused a great deal of interest in the profession. We have for years looked forward to the possibility of a drug that would numb the sensorium and make the patient oblivious to his surroundings and yet not act in a deleterious way on any of the vital organs.

Thierfelder and von Mehring<sup>1</sup> in 1880 made the observation, which was later confirmed by others, that the sleep-producing action of alcohol was related to the number of ethyl groups present. A few years later Schmiedeberg conceived the idea of producing a nitrogen-containing hypnotic, knowing that intravenous injections of ammonia preparations raised the blood pressure. Schmiedeberg succeeded in preparing urethan; and, following in the order named, paraldehyde, amylene hydrate, sulphonal, trional and chloroformamide were produced.

It was then observed that the intensity of the hypnotic action of sulphonal depended upon the number of ethyl radicals linked to a central carbonatom, and for this reason Fisher and von Mehring in 1903 successfully completed the synthesis of a nitrogen-containing compound with the formula:



This substance was prepared by treating diethylmalonic acid ester with urea and sodium ethylate. The preparation was placed on the market under the name of

“veronal,” the generic name of which is “barbital.”

Since that time a large number of barbit derivatives have been prepared, differing one from the other largely in the substitution of one or both hydrogen atoms by other radicals. It is possible to develop a great number of these substances.

In 1924 Fredet and Perlais,<sup>2</sup> two Frenchmen, succeeded in inducing general anesthesia with the barbituric acid series. They used a mixture of di-ethyl-allyl-barbiturate (trade name somnifene). This was administered intravenously. In 1927 Bumm,<sup>3</sup> following the lead of Fredet and Perlais, used a barbituric acid derivative intravenously. This compound he believed decomposed more readily than somnifene. He utilized sodium sec-butyl bromopropenyl barbiturate (trade name pernokton). He believed that the elimination of the pernokton was more rapid in the body and would permit a more rapid recovery from the anesthetic than would be possible with the other preparation.

In 1926 Page and Coryllos<sup>4</sup> used sodium iso-amyl-ethyl-barbiturate (trade name sodium amytal) to produce general anesthesia in animals. These animals went to sleep quietly and slept from two to six hours, and when they awoke they seemed fresh and showed no ill effects from the drug. A little later Page and Swanson<sup>5</sup> observed that the amytal stem was less toxic than the veronal.

In February, 1929 Zervas and McCallum<sup>6</sup> of the Research Department of the Indianapolis City Hospital reported the successful induction with this drug of general anesthesia in man in about 300 cases. In

\* Submitted for publication, May 17, 1930.



September of 1929 Lundy<sup>7</sup> of the Mayo Foundation reported at the Pan-Pacific Surgical Congress 1000 cases, surgical and medical, in which this barbital derivative had been used.

Our experience with sodium iso-amyl-ethyl-barbiturate began in July, 1929. Up to the present time it has been administered in the clinic to 305 patients. Our experience with the drug and our observations upon this group of cases are as follows.

#### PREPARATION AND ADMINISTRATION

We have received from the manufacturer sodium iso-amyl-ethyl-barbiturate in crystal form, put up in ampules of 0.5 gm., 1 gm., and 1.5 gm. With each ampule we have received an accompanying ampule of triple-distilled sterile water, which when added to the anhydrous salt makes a 10 per cent solution. The accompanying ampule of water is added to the salt and the mixture is shaken gently until it is dissolved. Ten minutes should be allowed for the solution to reach the proper hydrogen ion concentration. A few times the solution obtained has not been clear, and this has been immediately discarded for another solution. We have given it only intravenously and at the rate of a grain and a half a minute. All of our patients have had a preliminary medication of  $\frac{1}{6}$  to  $\frac{1}{4}$  grain of morphine sulphate and  $\frac{1}{150}$  grain of atropine sulphate one hour before the administration of the sodium iso-amyl-ethyl-barbiturate. Practically all of the patients have had the administration of the drug in the room. The usual precautions that are taken with general anesthetics of any kind should be taken with this one. The stomach should be empty, there should be no obstruction to the air passages, false teeth should be removed, and the chin held up. In one case of intravenous administration in which a considerable quantity of the solution was spilled into the tissues a sore arm resulted. The soluble salt in dilute solution may be injected intramuscularly or may be given

by mouth or by rectum. With these last three ways of administering the drug we have had no experience.

In view of the fact that there are individual variations in the action of almost all drugs, we have felt that the intravenous administration of sodium iso-amyl-ethyl-barbiturate afforded the best method of controlling the dosage. There is a general feeling that the same amount of the drug given by mouth or rectum is safer, but we do not believe that this is true. Once the drug is absorbed by any method it is not recoverable, but when given by intravenous injection the effects can be watched and the injection discontinued immediately when the patient falls asleep or loses consciousness. In case the drug is given by mouth or by rectum the entire amount is not absorbed and the desired effect may not be produced. If, on the other hand, the patient is one of those individuals whose tolerance is rather low too large a dose may be given. We believe that the intravenous injection, which has allowed us to take into consideration the individual variation in the action of the drug is the safest procedure.

#### DOSAGE

The lethal dose for man is unknown. In dogs Page and Coryllos and others have found the fatal dose to be approximately twice the dose necessary for general anesthesia. As Zervas and McCallum<sup>8</sup> have pointed out, man seems to be more susceptible to the anesthetic effects of the drug since he requires only one-third to one-half the amount per unit weight that is necessary for surgical anesthesia in animals.

There is a wide variation in individual susceptibility to the drug. The fact that the minimum dose required to barely erase consciousness varied frequently in our series from 3 grains to 9 grains illustrates how impracticable is any rule-of-thumb statement of dosage. In 1 case 17 grains were given before the patient lost consciousness, and in 5 more instances

12 grains each were required. This variation did not depend upon weight differences. In a few instances the resistance to the drug was attributed to accidental shortening of the interval between the preliminary morphine and the administration of the sodium amytal, but this could explain only a small group of cases. Factors of more importance seem to be the *age* and *general condition* of the patient. Thus old or debilitated people may fall asleep after 3 to 4 grains have been given, while young robust patients may require 7 to 9 grains before they lose consciousness.

For the first 50 cases we carried the patient beyond the stage of bare loss of consciousness and gave very large doses, 18 to 25 grains, and in one instance 28½ grains, in an attempt to secure surgical relaxation unassisted by other anesthetics; but we came to realize that the sodium barbiturate could not in the average case produce the desired surgical relaxation unassisted by other anesthetics. We therefore reduced the dosage, following the general rule of giving just twice the amount necessary to put the patient barely to sleep, so long as this did not exceed 22½ grains.

We feel, however, that this much is also unnecessary, so that now we stop the injection as soon as the patient falls asleep. In other words, at the present time we do not advise any more than a hypnotic dose, which takes out of the general anesthesia that excitement stage. However, we did not find the larger doses dangerous to the patient.

#### GENERAL EFFECT

By using a very small hypodermic needle attached to a 10 c.c. syringe the induction is not at all unpleasant. During the intravenous administration of the first 3 to 9 grains, in a room that is perfectly quiet, the patient slips away into a sleep that certainly to appearances closely resembles the physiological. Except in 1 case, there was no evidence of an excitement stage, either during the induction of sleep by the sodium amytal or during the

induction of deeper anesthesia by the superimposed inhalation anesthetics. In 8 instances the patient experienced laryngospasm, and with 3 of these patients the spasmodic coughing was so disagreeable that we stopped short in the administration of the drug.

The pupils become slightly contracted and in some cases fixed, so that they will not react to light. The corneal reflexes are diminished. The blood pressure in all but a few cases in our series fell, the systolic an average of 32 mm. of mercury, the diastolic an average of 16 mm., during the induction. It is worthy of note that this is the same average fall found in the first 165 surgical patients,<sup>9</sup> where larger doses were being given than in the last 100 cases. In other words, the average blood pressure fall is the same for bare induction of sleep as it is for deeper anesthesia. In some patients receiving as much as 18 grains of sodium amytal the blood pressure taken immediately at the completion of administration showed no reduction, while in others as little as 3 grains caused a systolic fall of 40 mm. of mercury. The greatest fall in systolic blood pressure was from 200 to 100 mm. of mercury. In 12 other instances the systolic fall was as much or more than 60 mm. In 5 of these instances the initial pressure was as high as 165 or more. In other words, it seems that a hypertension is more susceptible to reduction than is a normal blood pressure. In the large majority of these cases this reduction in blood pressure was so transient that the slightest motion or squirming on the part of the patient or the administration of inhalation anesthetic was accompanied by a restoration to normal. In no instance where ephedrine was administered early did it fail to restore the blood pressure.

The pulse rate, if elevated by emotional excitement, was reduced during the induction of the anesthesia. In all other cases, however, the pulse appreciably quickened after the injection of the sodium amytal. Respirations became shallow, and in some

cases the rate of respiration fell as low as 12 per minute. The color in all but a few cases has been uniformly good; in fact the complexion becomes rosy and sometimes resembles a febrile flush. The skin in most of the cases is dry, although in some there has been some moisture. The reflexes are diminished somewhat but never completely abolished.

#### THE PATIENT'S ATTITUDE TOWARD THE ADMINISTRATION

The reason we have continued the use of sodium amytal intravenously is because of the gratitude expressed by the patients who have received it. The most enthusiastic group are those who have had general anesthetics at some previous time. The ordeal of having to get onto an uncomfortable ward carriage, go to the elevator, be transferred to the surgical floor, and then from the ward carriage to be transferred to the operating table is more trying than we who have not been through it imagine. To get a glimpse of the operating room nurses and doctors all in white, and often to see and hear the rattle of the instruments as they are being transferred from one basin to another, and then to cap the climax to have something tight dropped over the mouth and nose to be relieved of all this is most gratifying. These patients state that instead of experiencing the most uncomfortable day of their lives, the day is passed without their knowledge, and when they awake late in the afternoon they find that the operation has been performed and they are safely back in their beds. Many of these patients, when told that the operation has been performed and that they are again back in their own room, are so much relieved that they will drop off to sleep again for two or three hours.

We have made it a practice to talk to these patients and to get their point of view, and it is because of their enthusiasm and because we feel that we have relieved them of a great amount of wear that we are more than willing to undergo the inconvenience that surrounds the administra-

tion of the drug. The necessity of having a special nurse for these patients, the occasional delay by the intern who administers the drug in the room, and the occasional delay in obtaining supplementary anesthesia, because the shallow respirations slow the inhalation of the general anesthetic, are rather annoying to the busy surgeon who has been accustomed to the old regime; but we feel that the relief and satisfaction that the patient derives far outweigh these minor difficulties.

For a long time this result has been attempted with various agents, scopolamine being outstanding. Sodium iso-amyl-ethyl-barbiturate has the advantage that it is sure in the accomplishment of the result desired, and at the time more exact in the degree of stupor or unconsciousness that it produces. The effect is reached immediately upon injection, if the sodium barbiturate is given intravenously; and by observation of the patient's reaction to it as the drug is administered he can with safety be carried to any of three states, as desired, i.e., cooperative stupor, deeper unruly stupor or total unconsciousness. We believe that it should not be used to carry the patient beyond this third stage, i.e., deep *relaxed* unconsciousness. Another great advantage of the sodium barbiturate is the almost total elimination of postoperative nausea and vomiting. In general use we secure a cooperative stupor for regional and spinal anesthesia, and the further stage of unruly stupor or bare unconsciousness where inhalation anesthesia is to be superimposed.

In spite of our encouraging results with combined sodium amytal and spinal anesthetics, reported in a former article, we have been slow to administer the 2 agents in combination since each may produce a fall in blood pressure. However, we have, with ephedrine, sustained normal blood pressure in the 12 cases in which the 2 have been used. The types of supplementary anesthesia we have used are outlined in Table II, the types of operation in Table I.

TABLE I

REGION OR TYPE OF OPERATION	
Breast.....	25
Thyroid.....	37
Nose.....	9
Face.....	2
Eye.....	3
Mastoid.....	5
Mouth.....	8
Hand.....	1
Glands of neck.....	1
Gall bladder.....	24
Kidney.....	12
Shoulder.....	3
Laparotomy.....	5
Appendix.....	19
Stomach.....	5
Small intestine.....	5
Cecum, colon, rectum.....	17
Pelvis.....	45
Perineum.....	13
Hernia.....	9
Varicocele.....	2
Cystoscopy.....	2
Spleen.....	1
Parathyroid.....	1
Cesarian sections.....	3
Amputation of leg.....	1
Chest.....	1
Repair of nerve.....	1
Application of cast.....	1
Total.....	261
Medical cases.....	37
Obstetrical cases.....	7
Total.....	305

TABLE II

SUPPLEMENTARY ANESTHETIC USED	
N <sub>2</sub> O — O <sub>2</sub> (85 per cent to 50 per cent).....	28
N <sub>2</sub> O — O <sub>2</sub> and ether.....	109
Local procaine or cocaine.....	15
Local procaine and N <sub>2</sub> O — O <sub>2</sub> .....	32
Spinal anesthesia.....	19
Ether.....	24
Total.....	227
Sodium amytal alone.....	34
Total.....	261

## CONTRAINDICATIONS

We feel that debilitated or elderly people should not have sodium amytal, nor should patients with respiratory obstruction. Patients with a very high or very low blood pressure, being poor risks, should not be subjected to an additional drug. We are not so certain that the very small hypnotic dose that we are using at the present time would be contra-

indicated in pulmonary infection; however, we have not given it to any patient with a cough preceding the operation. In practically any case where there was some particular indication because of extreme nervousness on account of the impending operation we would be inclined to advise a hypnotic dose because there is very little reaction to a small dose except to throw the patient into a very quiet peaceful sleep.

## UNTOWARD EFFECTS

During the administration of the drug in 3 instances there was a slight restlessness manifested and in 1 case a definite excitement stage, although in all the other patients the induction was quiet, and in these 4 patients quiet sleep was secured

TABLE III

POSTOPERATIVE COMPLICATIONS	
Nausea.....	4
Vomiting.....	39
Headache.....	5
Restless reaction.....	14
Drunken delirium.....	1
Hysterical psychosis.....	4
Deep cyanosis.....	2
Catheterization up to fifth day.....	6
Catheterization once or twice.....	55
Involuntary urination.....	2
Bronchitis.....	1
Pulmonary edema.....	3
Backache.....	4
Sore arm (from injection outside vein).....	2
Skin rash.....	1
Respiratory difficulty on table.....	9
Postoperative depression.....	3

by an additional amount of the drug. Laryngospasm, which has occurred in 8 of our cases, was in 3 of these cases accompanied by severe coughing. This comes on almost immediately after the patient falls asleep and ceases when the dose is increased or within fifteen minutes after the injection of the drug is discontinued. This complication will not occur, it is believed, if the drug is in clear solution and of proper hydrogen ion concentration.

As with other anesthetics, there is a relaxation of the tongue and pharyngeal muscles, and the jaw must be held forward

to prevent the tongue from falling back and causing cyanosis and suffocation. For this reason we always keep a special nurse at the bedside until the patient has reacted. Since we have reduced the dosage to the minimum described above, the patient is often half awake shortly after the operation and a special nurse is not necessary.

On occasions when sufficient time has not been allowed for the drug to dissolve completely or when it has been injected too rapidly the respirations have become irregular. The patient takes four to eight deep breaths followed by a pause. Respiration becomes regular within ten to twenty minutes.

There are a few untoward effects which have been manifested *on the operating table* when the patient is receiving inhalation anesthetic after having had sodium iso-ethyl-barbiturate; but in no one of these instances could the entire blame be put upon the barbiturate, for such difficulties have arisen during inhalation anesthesia when the barbiturate has not been used. A few times the patient has stopped breathing for short intervals, and in other patients deep cyanosis has occurred. Respirations may be stertorous and difficult occasionally. At no time has there been a death on the table.

When returned to the room the patient as a rule lies motionless and does not awaken to full consciousness for from one to eighteen hours. Usually he awakens in from one to three hours and is fully conscious in from six to ten hours. We have adopted the routine of giving a hypodermic injection of  $7\frac{1}{2}$  grains of caffeine sodium-benzoate and  $\frac{3}{8}$  grain of ephedrine sulphate during or just after operation if we feel there is any possibility of cerebral anemia or passive congestion from loss of circulatory tone.

The chief complication to be feared is pulmonary congestion, due to the shallow respirations, particularly was this possible in those patients early in this series who received large doses and lay motionless

for hours. All 3 of our cases of pulmonary edema were in the first of the series, where the larger doses were given. One of these patients developed frank pneumonia and died. As a prophylactic measure against this complication we now routinely ventilate the lungs with a mixture of 5 per cent carbon-dioxide and 95 per cent oxygen before the patient leaves the operating room and repeat this in the bedroom if the patient is slow in reacting. As soon as he reacts he is encouraged to take five or ten deep breaths at least once an hour.

When reacting from the anesthetic 6 per cent of our patients were more restless than normal, and one required a restraining sheet. Although in a twilight stupor, if such a patient is reassured, he will usually drop off to sleep again and awaken quietly several hours later. Morphine should be given early for such conditions. Sometimes the restlessness is due to overdistention of the bladder, and catheterization will be sufficient to quiet the patient. Twenty-one per cent of our patients have been catheterized once or twice and 2 per cent up to the fifth postoperative day. The large number of catheterizations is due in large part to the fact that all women who have received the drug are catheterized eight hours after the operation if they have not voided by that time. Three of these patients have developed cystitis, transient in nature.

One man, an alcohol habitué, reacted in a drunken delirium lasting eight hours, and 4 women developed depressive psychosis lasting several days. Two of these 4 were the only patients in the series who did not like the drug. Several patients complained of bad dreams.

There have been 9 hospital deaths in the surgical series and 3 in the medical. Excepting the case of postoperative pneumonia already mentioned, the cause of death was clearly explained without relation to the sodium iso-amyl-ethyl-barbiturate.

As far as traced, we have seen no *late* untoward effects from the drug.

## CONCLUSIONS

Sodium iso-amyl-ethyl-barbiturate used as a *preanesthetic*, with a dose just large enough to make the patient lose consciousness, has given us more satisfaction than any other drug we have used. In patients with Graves' disease and in those who are nervous, sensitive, or apprehensive it gives the most satisfying results. If given slowly and intravenously and the dose stopped as soon as the patient loses consciousness, we do not believe that one will ever experience any serious untoward effects.

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## VAGINAL SPECULUM AS INDIFFERENT ELECTRODE\*

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THERE are many lesions of the cervix that are better treated by electrocoagulation than by galvanocauterization. For several years I have used the vaginal speculum as the indifferent electrode, connecting it by a snap arrangement to one of the leads from the diathermy apparatus.

The advantages are ease of application, eliminating an extra piece of apparatus, and making snug and even application of a broad metallic surface to a moist mucous membrane. The danger of sparking the patient, as may happen with a poorly placed lead plate to the buttocks or abdomen, is eliminated.

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CLINICAL OBSERVATIONS ON THE RELATION OF  
SODIUM AMYTAL  
TO VASOMOTOR AND DIURETIC PHENOMENA AFTER ORAL ADMINISTRATION\*

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ANY drug which will produce sufficient hypnosis to spare the patient the dread of an operation without endangering, at the same time, the patient's life, or without creating difficulties in inhalation anesthesia, or without obscuring postoperative manifestations, must be welcomed as a desirable adjunct to pre-anesthetic medication. The barbituric acid derivatives as a group have been acclaimed to possess these properties in varying degrees. Their individual behavior is therapeutically and pharmacologically similar in every respect except that the degree of toxicity differs with each derivative.

Experimentally, diethyl barbituric acid or barbital (veronal) has the lowest toxicity or the widest safety margin (Eddy 1928,<sup>1</sup> Weiss 1929<sup>2</sup>), while the more complex derivatives present higher degrees of toxicity or lower safety margins. Apparently, the speed and degree of hypnotic efficiency of the individual derivative are somewhat proportionate to its degree of toxicity. In animal experiments, the derivatives which produce the most efficient and rapid hypnosis amounting to deep anesthesia have also proved themselves to be the most toxic (Eddy 1928<sup>1</sup>).

There are today a number of barbituric acid derivatives on the market offered under various trade names, such as barbital, veronal, allonal, ipral, phanodorn, pernocton, somnifene, luminal, dial, neonal, amytal and their respective sodium salts. For each there has been claimed a particular anesthetic virtue when used in sufficiently large doses. In all fairness one must say that such virtues exist. At the same time one must take into consideration experimental evidence pointing to the dangers accompanying the use of all of

these drugs. With the introduction of each of these drugs, invariably an enthusiastic group of supporters has made special claims for the anesthetic value of the particular derivative, later to be followed by less enthusiastic reports based on intensive observations by the more cautious. The controversies on somnifene in the French literature between 1924 and 1926 and on pernocton in the German reports of 1927 to 1929 are typical for divergence of opinions. Although the pharmacologists of this country have for a number of years used the barbiturates for their anesthetic properties in animal experimentation, clinically they had not been used on a large scale for anesthetic purposes until about 1928. Recently interest has been evinced in the action of sodium isoamylethyl barbiturate appearing under the trade name of sodium amytal, and courteously offered by the manufacturers to a number of investigators for clinical and experimental observations.

At the Stanford School of Medicine we recently have been supplied with a sufficient amount of the drug for detailed studies. Holman reports the results of his observations in general surgical procedures in the present issue of this journal. We wish to add certain observations on gynecological and obstetrical patients, which form part of a study of the clinical value of barbituric acid derivatives as anesthetic adjuncts. Studies in changes of blood pressures, diuretic phenomena including sulphophenolphthalein excretions and toxic phenomena are the particular points discussed in the following paragraphs.

We accept without comment the dramatic and highly hypnotic action of sodium amytal as originally stated by the various

\* Submitted for publication May 22, 1930.

observers of the Indianapolis group.<sup>3</sup> Our aim in this study is a search for more minute information regarding dangers following the administration of the drug. In the earlier part of our acquaintance with sodium amytal we followed, in regard to its administration, the original recommendations made by Zerfas and McCallum.<sup>3</sup> Like everybody else, we were then greatly impressed by the dramatic action of the drug. Later it was decided to administer the drug by mouth, and since no material difference was observed in its general action hypodermic administration was abandoned for the more simple oral medication. With the exception of obstetrical patients, most of our observations presented here were made after this period. Our technic of administration was essentially this: About one-half to one hour before operation the patient, designated as Group A, received 15 grains of sodium amytal by mouth. In addition, one-sixth to one-fourth of a grain of morphine sulphate was given hypodermically prior to taking the patient to the operating room. The only clinical difference between intravenous and oral administration, aside from being able to gauge the dose slightly more accurately, is the speed and length of the reaction. After oral administration the maximum reaction appears from five to ten minutes later and is slower in wearing off in the postoperative period.

In another group used for comparative studies in diuretic reaction, designated as Group B, sodium amytal was replaced by scopolamine. In this group the patient received 1/300 of a grain of scopolamine hypodermically one hour before the operation and again thirty minutes later. In addition, one-sixth to one-fourth of a grain of morphine sulphate was administered hypodermically prior to sending the patient to the operating room.

In 21 patients we have studied the immediate and more remote effects of sodium amytal and morphine on blood pressure. We found essentially the same

reactions as reported by other observers for intravenous administration of the drug. In 19 patients the systolic pressure dropped from a few millimeters to 40 mm. within ten to twenty minutes after the sodium amytal had been taken by mouth, while the diastolic pressure usually decreased from 10 to 15 mm. occasionally falling from 20 to 25 mm. for a period of about twenty minutes. Toward the end of an hour the systolic pressure usually had risen to within 50 per cent or more of its primary drop, the diastolic pressure remaining essentially the same. Only once did we see the pressure rise above the normal after thirty minutes, and once it remained practically stationary.

Operative procedures were begun from thirty to sixty minutes after the ingestion of the drug. Regardless of the age and weight of the patient or the length of the operation we have observed that during the operation in the majority of instances the systolic and diastolic pressures rose from 10 to 20 and occasionally 30 mm. above the average normal pressure. Frequently this was accompanied by a rise in pulse rate from 10 to 20 beats over the normal, although respiration remained unaltered or slightly depressed as observed by others. Just how to interpret this phenomenon we do not know, but do not believe it to be due to the added effect of morphine since the blood pressure promptly returns to a normal level after the termination of the operation. It is possible that the body position has to do with the reaction since we operate on our patients in a 30° Trendelenburg position. We also supply the patient with fluid by hypodermoclysis during the entire duration of the operation. This, too, may have a bearing on the sudden increase in pressure. We doubt that operative manipulation has anything to do with this phenomenon since we have reduced the handling of tissues to a minimum, paying particular attention to the avoidance of any pulling on the pelvic viscera. We are under the impression that patients operated upon



TABLE I

BLOOD PRESSURE OBSERVATIONS BEFORE, DURING, AND AFTER OPERATION. THE PERIOD OF OPERATION IS MARKED BY A HEAVY LINE AT EITHER END

Name	Basic B.P.	10"	20"	30"	40"	50"	1 hr.	1'15"	1'30"	1'45"	2 hrs.	2'15"	2'30"	2'45"	3 hrs.	3'30"	4 hrs.
AN.....	184/90	174/94	138/70	134/68	134/76	134/70	150/90	.....	.....	.....	105/60	.....	110/60	.....	120/80	.....	108/60
RR.....	120/78	115/80	.....	100/80	90/70	.....	95/70	100/82	140/80	160/95	150/90	130/100	135/95	130/95	128/80	140/90	125/80
MN.....	116/64	92/60	100/72	.....	125/85	120/80	100/70	110/70	120/80	140/90	140/90	130/90	140/90	140/90	120/80	120/80	104/60
KE.....	134/86	100/70	96/74	94/76	94/70	.....	.....	.....	140/95	145/100	165/110	140/100	135/95	.....	.....	.....	.....
CS.....	174/100	150/?	98/?	125/?	140/110	.....	140/110	.....	150/105	150/100	155/100	160/100	170/95	.....	170/100	.....	.....
BI.....	118/78	102/80	.....	100/70	.....	.....	100/70	120/100	.....	110/90	.....	100/80	.....	110/80	.....	.....	118/76
BN.....	116/78	106/65	.....	100/60	.....	110/70	130/75	125/75	110/65	.....	106/65	.....	.....	.....	100/60	.....	.....
MN.....	132/94	92/68	.....	86/60	.....	120/100	150/120	145/110	140/110	135/95	140/100	.....	.....	.....	140/100	.....	.....
KT.....	110/80	100/80	100/80	.....	98/80	120/90	125/95	130/100	130/105	135/100	125/95	110/90	100/85	125/95	120/100	115/100	115/95
HY.....	110/70	100/60	90/50	100/60	96/112	.....	100/60	.....	110/80	105/80	105/80	.....	105/80	.....	96/84	.....	.....
DS.....	100/60	104/55	102/57	80/58	80/?	90/50	108/58	.....	120/60	.....	130/90	.....	125/95	.....	110/90	.....	.....
BN.....	114/80	94/66	88/62	102/80	96/72	110/88	90/60	.....	110/80	.....	110/75	.....	120/90	.....	.....	.....	.....
KY.....	118/70	.....	118/70	118/70	128/80	120/70	125/80	.....	110/70	.....	.....	.....	.....	.....	.....	.....	.....
BR.....	170/112	136/110	155/118	190/130	160/120	154/116	152/116	135/100	.....	155/100	.....	190/100	165/100	160/100	160/112	.....	160/112
EY.....	140/76	118/80	110/70	124/70	136/90	130/90	.....	135/95	.....	140/95	130/90	140/95	.....	.....	.....	.....	.....
SE.....	110/60	82/?	72/?	68/?	84/?	110/60	.....	128/65	.....	110/60	.....	115/60	.....	.....	110/65	.....	.....
BT.....	122/88	98/66	90/65	110/75	105/70	105/70	110/80	120/90	130/10	120/85	130/100	135/110	140/90	140/100	140/105	.....	105/70
KE.....	124/84	100/64	80/2	100/80	110/74	.....	84/50	90/50	110/70	130/95	90/50	.....	.....	.....	.....	.....	.....
IN.....	146/94	128/72	102/66	110/74	120/90	50/120	180/115	170/120	175/120	165/110	.....	.....	.....	.....	150/95	.....	.....
OE.....	124/76	104/69	100/70	102/84	100/70	105/75	105/80	105/85	110/85	108/65	110/65	112/70	112/70	.....	90/62	.....	.....
DY.....	105/78	100/75	98/75	85/70	105/80	.....	85/70	.....	105/80	.....	105/85	.....	.....	.....	106/80	.....	.....

under scopolamine and morphine do not present this rise of pressure, although we have not made an intensive comparative study. This change in blood pressure has particularly interested us since Zerfas and McCallum<sup>4</sup> and Lundy<sup>5</sup> have apparently not encountered it in their large series. It will need further comparative studies before we will permit ourselves to come to any conclusions. We can state, though, that this particular rise in pressure has not given us any trouble in hemostasis.

We have nothing to add to the present knowledge of the influence of sodium amytal on respiration and pulse rate. There is no doubt that respiration is depressed by the amount we have used orally, necessitating at times the use of caffeine sodium benzoate which, when given in sufficiently large doses to counteract the depressing effect of sodium amytal, also defeats the hypnotic action of the drug to a marked degree. An alarming collapse of the vasomotor apparatus we have seen only once in our entire experience. This occurred in a patient whom we had slated for an abdominal operation because of miscarriage from a double uterus. The patient passed the gestation product while being prepared in the operating room and the product was removed intact from the cervix without any particular bleeding. After the patient was returned to her room the pulse rate and temperature rose within a few minutes to 160° and 105°F. respectively in the entire absence of symptoms of shock and bleeding but in the presence of marked cyanosis and respiratory depression. Since no instrumentation took place and bleeding was very slight, we ascribed this to the action of sodium amytal, particularly so since pulse, respiration and temperature returned to normal within a few hours after vigorous counter measures had been instituted.

In various instances of respiratory depression early during the inhalation anesthesia ephedrine and caffeine both had to be used. To our way of thinking the necessity of having to resort to counterstimu-

lants frequently is a decided drawback to this particular barbiturate. We found it rather disturbing that our vigilance over the patient during twenty-four hours after the ingestion of the drug had to be increased to a degree where it became a burden to those connected with the supervision of the patient. It cannot be denied that while deep hypnosis lasts anesthetists, assistants and nurses are in a state of uneasiness. Although the patient may be most grateful for having been spared the dread of the operating room and the fear of pain often following immediately after awakening from the anesthetic, the added work for the attendants is a disturbing factor and requires further search for the ideal dosage or the use of a less toxic barbiturate.

Severe confusion following the use of sodium amytal we have encountered in three instances. On the other hand visual disturbances, lack of orientation, restlessness, and latent intestinal consciousness are present in one form or another in about 25 per cent of all patients observed by us. It was of particular interest to us that restlessness, with accompanying insomnia and intestinal consciousness in the absence of distension, was latent. This rarely appeared until the second or third day and at times was very annoying to the patient. Making allowance for the action of pantopon, which we used exclusively as a postoperative narcotic, we still believe that the sodium amytal is responsible for these phenomena for they are absent in our scopolamine group. The latent clinical manifestations cited here may be connected with lagging excretion of the drug similar to barbital, which has been shown experimentally to be excreted slowly over a period of several days (Gower & Tatum, 1929).<sup>7</sup>

Our experience with a combination of regional anesthesia, using novocaine 2 per cent, and sodium amytal by mouth, has been very disappointing. Following the injection of novocaine the patient becomes restless in spite of additional

nitrous oxide inhalation. Experimental evidence has proved in animals that the two drugs have an antagonistic action which in our experience seems to hold good for man, although Zerfas and McCallum<sup>4</sup> report satisfactory results from regional anesthesia when sodium amytal given intravenously is used in conjunction with novocaine. Since any barbituric acid derivative apparently is equally efficient in counteracting the toxic effect of the members of the cocaine group we do not see any particular reason for using sodium amytal for its detoxicating action alone. We have found that barbitol, for instance, will serve the same purpose, and when given judiciously in divided doses together with sodium bromide, will also produce a sufficient state of hypnosis to alleviate the dread of the operation with an added advantage of a much greater safety margin in toxicity. We are studying at present the usefulness of this drug for its preanesthetic value when combined with scopolamine and pantopon, and so far we are well satisfied with the results. It has been our experience that a sodium amytal patient, even under nitrous oxide anesthesia, frequently becomes restless as soon as the novocaine takes effect. This reaction was sufficiently lasting to be annoying to our anesthetists. We also were under the impression that hypnosis was definitely lightened by the amount of novocaine used by us. We therefore have abandoned this combination as unsatisfactory.

Our results of the use of 6 to 7½ grains of sodium amytal given intravenously in labor corresponds to the observations made by others.<sup>6</sup> The drug efficiently provides a period of rest of from one to three hours, but beyond that does not offer any advantages over other barbiturates. Blood pressure reactions are essentially the same as recorded here except that the drop is not as pronounced and not as lasting. An increased pulse and a decreased respiratory rate are invariably seen. The fetal heart rate, after allowing for its variations during uterine contractions, does not seem to be

influenced. In repeated doses the reactions in the mother are the same. We have been wondering whether this holds good for the fetus. In two instances the heart rate slowed down materially after the second dose, necessitating immediate delivery. One child was stillborn and the other markedly asphyxiated, later dying of non-specific hemorrhagic disease of the bowel. In either case we do not care to charge the end-result to the action of repeated doses of sodium amytal given intravenously, but call attention to the possible relation of repeated doses to a collapse of the vasomotor system of the fetus.

Recently we have interested ourselves in the relation of sodium amytal to diuretic reactions. Earlier casual observations seemed to suggest a retardation of fluid output. We, therefore, undertook to study two groups of patients submitting to operations of essentially the same type and severity. In Group A we have placed 19 patients having received sodium amytal and morphine, and in Group B 17 patients having received scopolamine and morphine according to the method of administration previously stated. With few exceptions routine hypodermoclysis during the entire length of the operation was used to establish a fluid balance, about from 1000 to 1500 c.c. being allowed to accumulate in the tissues of the thighs. Readings on fluid intake and output were then recorded for each twenty-four hours on three consecutive days beginning with the start of the operation. Vomiting is very rare in sodium amytal-morphine patients and uncommon in scopolamine-morphine patients, although nausea is often present in the latter group. We have excluded the occasional vomiting patient from this study. In the following tables and charts our observations are recorded in actual figures and graphic expression:

In the interpretation of these tables and charts one naturally must make allowance for the great variability in the constant of fluid intake and output. One, furthermore, should make allowance for all possible

TABLE II  
SODIUM AMYTAL AND MORPHINE  
TOTAL INTAKE AND OUTPUT ON THREE INDIVIDUAL DAYS, INCLUDING THE DAY OF OPERATION

Day of Operation			First Day P.O.		Second Day P.O.		Day of Operation	First Day P.O.	Second Day P.O.
Name	Intake	Output	Intake	Output	Intake	Output	Per Cent	Per Cent	Per Cent
	c.c.	c.c.	c.c.	c.c.	c.c.	c.c.			
BN.....	810	690	600	580	760	720	85.19	96.97	94.74
KT.....	1520	670	1170	495	1020	1080	44.08	42.31	105.88
MI*.....	1550	265	1140	210	2550	1671	17.10	18.42	65.53
IN.....	2100	470	1800	420	1500	900	22.38	23.33	60.00
AN*.....	2220	300	2520	330	2250	1200	13.51	13.10	53.33
KE.....	2220	760	1980	800	2400	1230	34.23	40.40	51.25
BI*.....	2610	630	1560	1380	2040	2070	24.14	88.46	101.47
BT*.....	2630	1380	2340	1740	1800	2130	52.47	74.36	118.33
HY*.....	2640	420	1530	720	1560	1290	15.90	47.06	82.69
EY*.....	2900	430	2100	1050	1680	900	14.83	50.00	53.57
BR*.....	2940	240	2030	780	1740	900	8.16	38.42	51.72
SE*.....	2960	600	3600	1170	3210	1890	20.27	32.50	58.88
ME*.....	3000	100	3160	840	1770	930	3.33	26.58	52.54
RS*.....	3280	600	1500	630	1890	570	18.29	42.00	30.16
KE*.....	3290	750	1410	1020	1650	1020	22.80	72.34	61.82
BN*.....	3290	630	1650	1560	1560	900	19.15	94.55	57.69
MN*.....	4390	660	1900	1080	3260	1650	15.03	56.84	50.61
CS*.....	4605	420	2070	1290	2070	1200	9.12	12.33	57.97
DS*.....	4630	840	1560	1170	1640	720	18.14	75.00	43.90

\* Indicates routine hypodermoclysis during operation.

variations depending upon age and type of patient, length and severity of the operation, and the recuperative faculties of the individual. It, therefore, is essential that one disregard the single observation because of the individual variation, and limit this study to group reactions.

Patients having received sodium amytal and morphine as a preliminary to inhalation anesthesia take in more fluid in the twenty-four hours following the operation than do patients having received scopolamine and morphine. At the same time urinary output is actually and relatively decreased in the sodium amytal group. Our original figures, not detailed here, show that sodium amytal patients take fluid by mouth more readily on the day of and the day following the operation

because of the greater freedom from nausea.

In the second twenty-four hours the fluid intake in both groups reaches fairly equal levels, but the ratio of output again presents a lower average in the sodium amytal group. In the scopolamine group the urinary output at times exceeds the fluid intake during this period. This is of interest because the same phenomenon does not appear in the sodium amytal group until twenty-four hours later.

In the third twenty-four hours the average fluid intake of the sodium amytal group rises slightly above the scopolamine group, while the ratio of output to intake reaches more similar levels.

Our observations recorded in Table iv, the figures of which are graphically

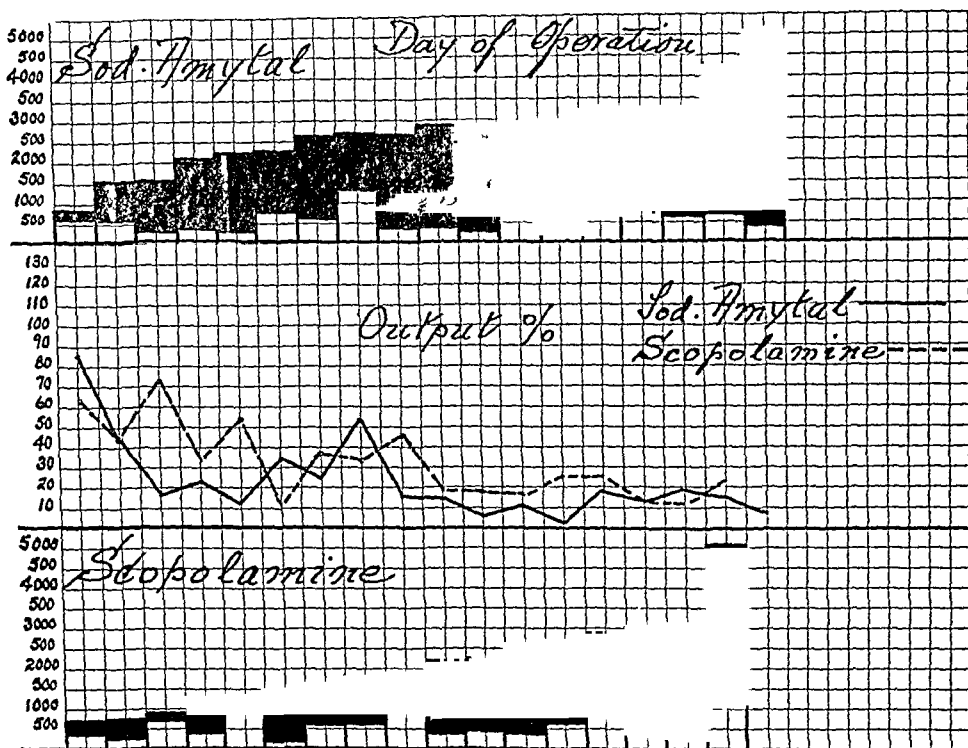


FIG. 1.

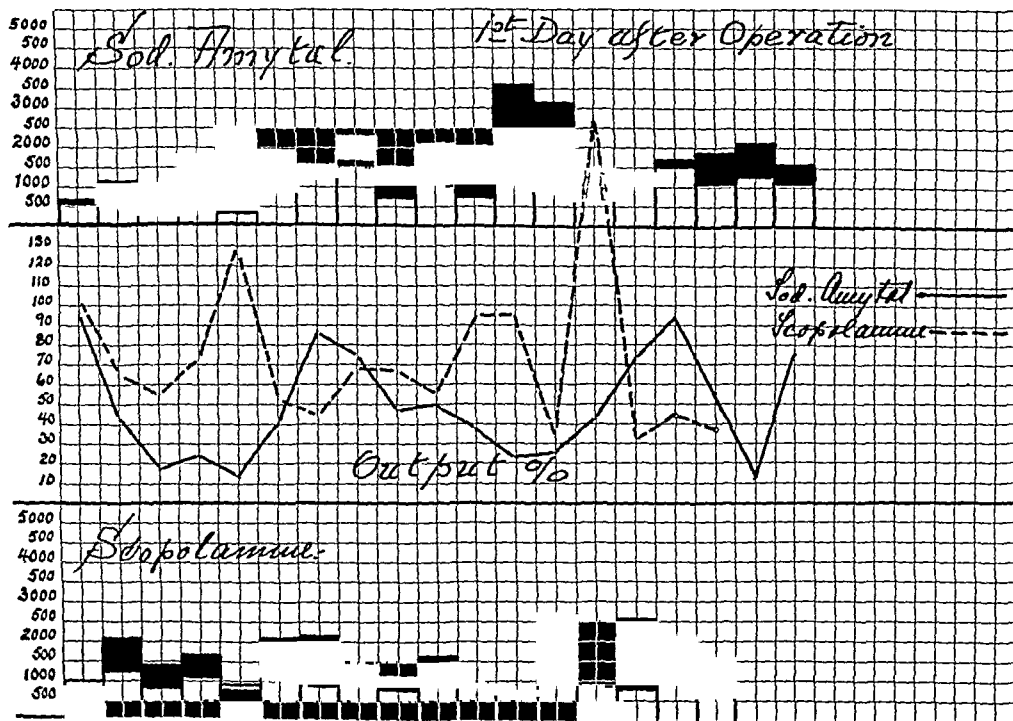


FIG. 2.

TABLE III  
SCOPOLAMINE AND MORPHINE  
TOTAL INTAKE AND OUTPUT ON THREE INDIVIDUAL DAYS, INCLUDING THE DAY OF OPERATION

Day of Operation			First Day P.O.		Second Day P.O.		Day of Operation	First Day P.O.	Second Day P.O.
Name	Intake	Output	Intake	Output	Intake	Output	Per Cent	Per Cent	Per Cent
	c.c.	c.c.	c.c.	c.c.	c.c.	c.c.			
FR*	650	410	930	950	1200	1400	63 08	102 15	116 67
RL.	750	330	2050	1350	2200	1350	44 00	65 85	61 36
PR	930	720	1480	810	1620	950	72 42	54 73	58.54
SN*	1340	420	1640	1170	incomplete		31 34	71 34	
RE	1440	780	700	900	1500	1120	54 17	128 57	74 67
CN*	1500	150	2080	1110	1680	240	10 00	53 37	14 29
KL	1665	630	2115	900	2250	2010	37 84	42 55	89 33
FE*	1750	570	1430	990	incomplete		32 57	69 23	
LS*	1800	840	1160	780	1900	1100	46 67	67 24	57 89
TT*	2265	440	1630	897	1530	1620	19 43	55 03	105 80
BA*	2440	480	945	900	1095	1065	19 67	95.24	97 26
CS*	2600	390	750	720	960	600	15 00	96 00	62 50
HN*	2720	660	2720	900	780	540	24 26	33 09	69 23
KY*	2830	720	480	930	1590	900	25 44	193 75	56 60
LH*	3060	375	2520	775	2100	1320	12 25	30 75	62 86
CN*	3225	355	2130	960	1950	840	11 01	45 07	43 07
AN*	5060	1020	1560	600	1740	600	21 60	38 46	34 00

\* Indicates routine hypodermoclysis during operation.

expressed in Chart iv, give the total results of fluid intake and urinary output during the three days referred to here. The graphic chart clearly shows the great variation in individual fluid intake in both groups with a persistently higher intake in the sodium amytal group. The curves otherwise run a fairly parallel course. The output curves, aside from a few variations, also simulate each other with an apparently slightly higher level in the sodium amytal group. While in this group there is apparently a greater output, it is only relative, for when compared to the intake, as expressed graphically in the percentage curve of Chart iv, it is actually lower in the general average. In other words, when one compares all factors cited here one cannot help but feel that sodium amytal, while it favors a greater fluid intake because of the absence of nausea,

depresses and retards diuresis when compared to similar studies with scopolamine. The possibility of a depression of water metabolism (Barbour, Hunter, and Richey <sup>9</sup>) due to morphine exists in both groups in about equal proportion and while, perhaps, an individual factor, becomes, therefore, negligible in its importance in a group study such as this. Barbitol is excreted almost entirely through the kidneys. Its excretion is slow, taking from two to three days to be eliminated (Paolini 1928, Gower and Tatum 1929, Eddy 1929<sup>7</sup>). There seems to exist a selective fixation for barbitol in the nervous system and the blood corpuscles, which may explain the prolonged period of excretion (Pucher 1925, Fabre et Fredet 1925, Paolini 1928<sup>8</sup>). Since the pharmacological reactions of the barbituric acid derivatives are essentially the

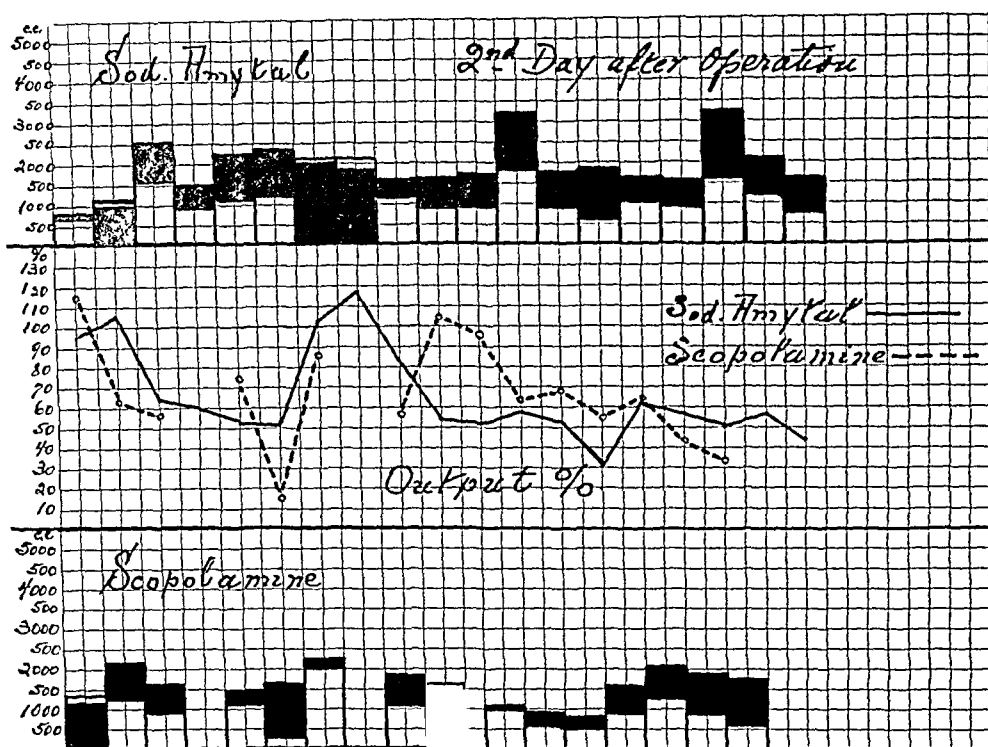


FIG. 3.

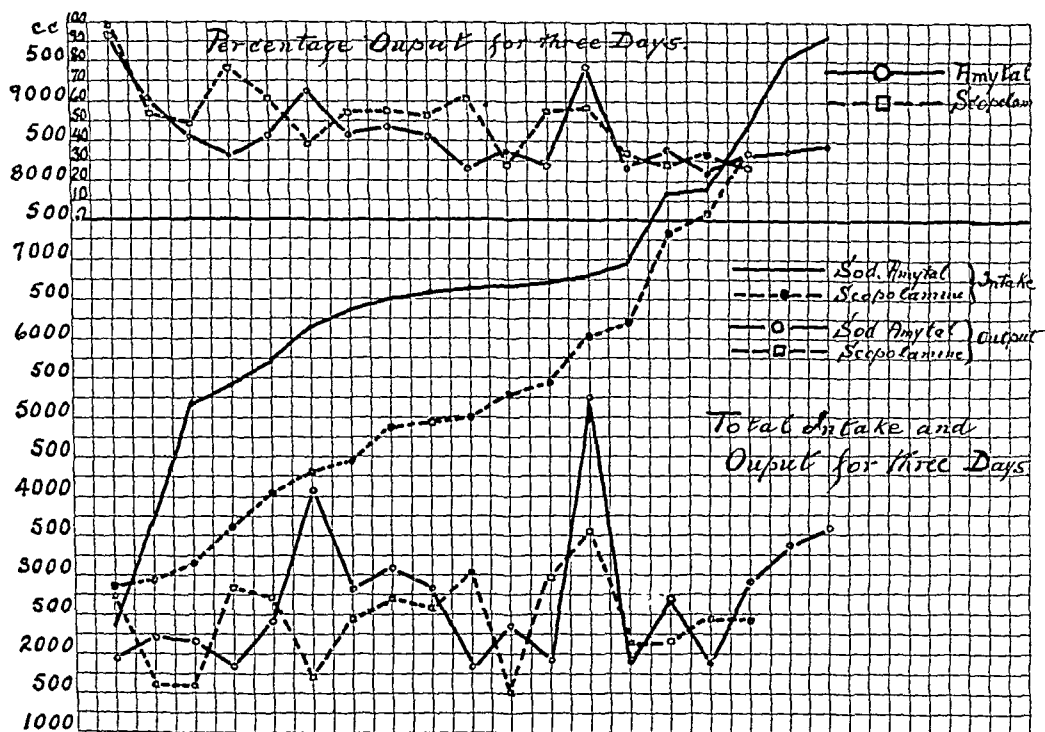


FIG. 4.

TABLE IV  
TOTAL INTAKE AND OUTPUT FOR THREE DAYS  
SODIUM AMYTAL SERIES SCOPOLAMINE AND MORPHINE SERIES

Name	Age	Total Intake	Total Output	Output Percentage	Name	Age	Total Intake	Total Output	Output Percentage
		c.c.	c.c.				c.c.	c.c.	
BU	40	2130	1990	93 43	FN	65	2780	2760	99 28
KT	36	3710	2245	60 51	SN	24	2980	1590	53 36
MI	22	5240	2146	40 95	FE	25	3180	1560	49 06
IN	40	5400	1790	33 15	RE	34	3640	2800	76 92
HY	33	5730	2430	42 41	PR	24	4030	2480	61 54
BI	40	6210	4080	65 70	CS	38	4310	1710	39 68
KE	45	6350	2790	43 94	BA	44	4480	2445	54 58
BN	38	6500	3090	47 54	LS	50	4860	2720	55 97
KE	56	6600	2790	42 27	KY	42	4900	2550	52 04
RS	27	6670	1800	26 99	RL	33	5000	3030	60 60
EY	42	6680	2380	35 62	CN	36	5260	1500	28 52
BR	30	6710	1920	28 61	TT	43	5425	2957	54 51
BT	43	6770	5250	77 55	KL	50	6030	3540	58 71
AN	61	6990	1830	26 18	HN	33	6220	2100	33 76
DS	28	7830	2730	34 87	CHN	40	7305	2155	29 50
MR	40	7930	1870	23 58	SH	47	7680	2470	32 16
CS	53	8745	2910	33 27	AN	37	8360	2400	28 71
MN	40	9550	3390	35 50					
SN	36	9770	3660	37 46					

same we may assume for the present that the factors just cited most likely hold good also for sodium amytal. It is therefore of interest that the clinical use of sodium amytal influences diuresis by depressing and retarding it. While in animal experimentation with barbital relatively larger doses have been used, the diuretic phenomena observed by us fit in well with animal observations. It would be of importance to learn more about this reaction in its relation to larger doses of sodium amytal administered. Because of the narrow safety margin of this drug we do not feel ourselves justified to undertake such a study. Those who administer sodium amytal in larger doses than used by us could easily study the associated diuretic phenomena in order to determine if such an increase in dosage leads to a greater retardation and depression of diuresis than we have encountered.

In connection with our diuretic study we undertook, whenever feasible, to investi-

gate glomerular activity as expressed in percentage of recovered sulphophenolphthalein in the urine administered intravenously according to the present standard technic. Here, again, one must make the usual allowances for a host of influences creating variations. We have contented ourselves by establishing before operation a normal for the individual after some hours of rest in bed. Here again we have resorted to a group study, disregarding individual comparisons.

After making all the possible allowances which might influence sulphophenolphthalein excretion we concluded that there was no essential difference between the two groups studied. The well-known variations in normal run approximately parallel. On the day of operation there is a marked drop from this level slightly more evident in the sodium amytal group, but not sufficiently pronounced to be of interest. Twenty-four hours after operation there appears a typical recovery curve approach-



TABLE V

SULPHOPHENOLPHTHALEIN EXCRETION BEFORE OPERATION, ON THE DAY OF OPERATION, AND DAY AFTER OPERATION

SODIUM AMYTAL AND MORPHINE SCOPOLAMINE AND MORPHINE

SODIUM AMYTAL AND MORPHINE								SCOPOLAMINE AND MORPHINE							
		Before Op.		Day of Op.		Day after Op.				Before Op.		Day of Op.		Day after Op.	
Name	Age	C.c. Urine	Per Cent Ph Th	C.c. Urine	Per Cent Ph Th	C.c. Urine	Per Cent Ph Th	Name	Age	C.c. Urine	Per Cent Ph Th	C.c. Urine	Per Cent Ph Th	C.c. Urine	Per Cent Ph Th
AN.....	61	700	42	95	37	125	30	CN.....	40	205	40	70	37	350	58
MN.....	40	320	47	270	27	250	30	BH.....	47	620	45	80	48	80	60
IN.....	40	450	47	100	28	170	41	TT.....	43	560	52	110	35	267	67
KY.....	23	450	53	110	53	400	42	RL.....	33	750	58	60	4	320	55
KT.....	36	460	55	60	15	325	50	SH.....	47	130	58	50	47	50	31
BN.....	38	550	59	80	27	125	50	CS.....	38	600	50	80	38	350	42
BR.....	30	480	57	100	40	220	42	FR.....	65	1225	59	115	52	100	45
EY.....	42	600	57	100	45	90	80	KY.....	42	725	60	70	28	470	61
RS.....	27	580	58	150	20	430	40	FE.....	25	1050	60	220	35	375	68
HY.....	33	510	58	115	40	300	55	RE.....	34	1230	60	90	50	350	50
SE.....	36	525	58	100	50	160	30	PR.....	24	960	65	80	35	265	47
KTE.....	56	820	61.5	400	50	350	40	CL.....	29	960	65	80	35	280	47
DS.....	28	575	65	110	35	200	50	SN.....	24	410	65	175	55	430	60
KE.....	45	475	65	90	35	400	48	HN.....	33	675	73	135	70	100	90
MI.....	22	600	67.5	260	45	410	50	LS.....	50	950	98	72	27	400	88
BT.....	43	675	73	135	20	240	60								

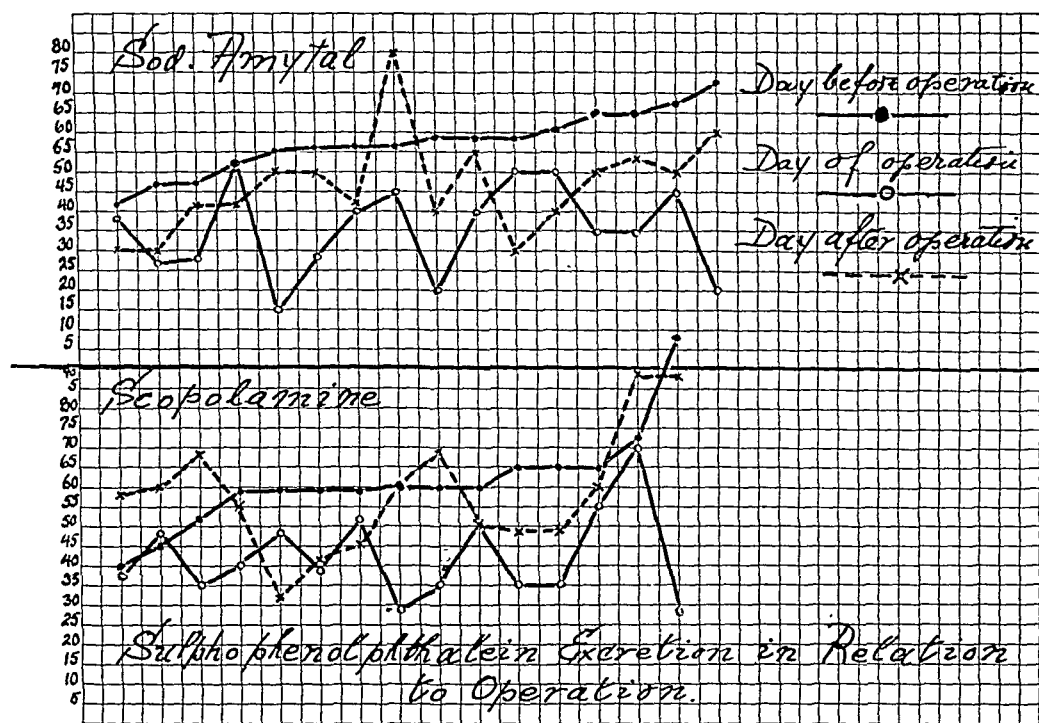


FIG. 5.

ing the normal. The dissimilarity between the two groups at this period is again negligible. If we may use this test as an indicator for glomerular activity we might

conclude that the diuretic depression and retardation observed by us clinically is not the result of the action of sodium amytal on the glomerular apparatus but

rather a tissue manifestation expressing itself in a reluctance to give up stored fluids because of a depression of the

when given in conservative doses is an efficient hypnotic. Because of its narrow safety margin it is not a desirable drug



FIG. 6.

vasomotor system. Such an assumption would fit more readily in with the observations made on latent excretions of barbitol.

Recently we attempted a similar clinical study in parturient women. It was at once obvious to us that diuretic studies embracing intake and output offered insurmountable obstacles because of the upsets of labor. But we carried out a comparative study on sulphophenolphthalein excretions during and following labor without establishing a previous normal. Twenty-one patients received from 6 to  $7\frac{1}{2}$  grains of sodium amytal intravenously in the first stage of labor after the sulphophenolphthalein test had been done. The second stage of labor was managed under nitrous oxide analgesia. The test was repeated after twenty-four hours. The results, when compared to an equally large group of controls, express an absence of any influence of sodium amytal on the glomerular activity, which in accordance with our previous observations.

Our conclusions are that sodium iso-amylethyl barbiturate or sodium amytal,

when the degree of hypnosis required depends upon a dosage which approaches 50 per cent of the minimal lethal dose for animals. When used solely for the purpose of preanesthetic hypnosis, while efficient, it is not superior to other barbituric acid derivatives possessing greater safety margins.

There is no particular advantage of intravenous over oral administration except that in the former hypnosis is more rapid and perhaps of shorter duration in the postoperative period.

A combination of oral administration and regional anesthesia with novocaine has been unsatisfactory in our hands. We believe that the detoxicating effect of sodium amytal on the cocaine derivatives is also accompanied by a reversed action in which the latter group of drugs counteracts the hypnotic depths produced by sodium amytal. The sole use of the drug for the purpose of counteracting the toxicity of the cocaine group, while efficient, is of no advantage since the same can be achieved by the administration of barbitol by mouth.

Our observations on blood pressure, pulse rate and respiration coincide with those of other observers. In addition, we have noticed a secondary rise of blood pressure during operation in patients receiving sodium amytal by mouth. Since we have not compared this phenomenon with reactions of other preanesthetic drugs and since position of the patient and hypodermoclysis may be responsible for this reaction we prefer not to ascribe it to a secondary action of sodium amytal on the vasomotor system.

We feel certain that immediate and latent nervous manifestations such as confusion, lack of orientation, visual disturbances and intestinal consciousness are attributable to the action of this drug, and these, together with the necessary intensive vigilance over the patient during the duration of hypnosis, constitute a serious drawback to the use of the drug.

Studies in diuresis lead us to believe that sodium amytal as administered by us favors fluid intake, but is equally responsible for an actual and relative depression of urinary output in surgical patients. Sulphophenolphthalein studies suggest that this reaction is not due to a depres-

sion of glomerular activity but has to do with a vasomotor failure to remove fluids from body tissues.

We have nothing to add to the knowledge of the behavior of sodium amytal administered intravenously to parturient women, but feel that caution is needed when repeated doses are given since the possible accumulative effect on the fetus has not been studied.

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# ANESTHESIA AND ANALGESIA

BY THE INTRAVENOUS ADMINISTRATION OF SODIUM AMYTAL\*

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I N February 1929 Drs. L. G. Zerfas and J. T. C. McCallum and their associates at the Medical Research Department of the Indianapolis City Hospital successfully demonstrated the induction of surgical analgesia and anesthesia in man by the intravenous injection of solutions of sodium amytal.†

In a consideration of any surgical operation it is highly desirable to differentiate

†Sodium amytal (sodium iso-amyl-ethyl barbiturate) is used in solution at a concentration of 5 or 10 per cent. To prepare the 10 per cent solution, break off the sealed ends of the ampoules containing the dry, powdered sodium amytal and the distilled water. Slowly introduce the water into the ampoule containing the powder, either directly or by means of a sterile syringe, rotating the ampoule so as to facilitate solution of the sodium salt. Sufficient time should be allowed to permit complete solution of the powder and the escape of all air bubbles. This may require a period of several minutes. *Under no circumstances should any solution be injected which is not absolutely clear.* Occasionally an ampoule may show a slight degree of opalescence or haziness, in which case, a fresh solution should be prepared. Solutions of sodium amytal are influenced by exposure to air and should, therefore be used within fifteen to thirty minutes of their preparation, and any remaining solution should be discarded.

The rate of administration intravenously should not exceed one cubic centimeter per minute.

When sodium amytal is used alone to produce anesthesia, under no circumstances should more than 25 mms. per kilo, or 0.175 grains per pound of body weight be used. Also the maximum dose should under no circumstances exceed 1.6 gms. or 25 grains. These limits should be rigorously maintained in view of the fact that the lethal dose for man is as yet unknown.

clearly two distinct physiological reactions: the first is analgesia, a loss of pain sense, and the second is narcosis, with or without analgesia.

The term anesthesia presupposes a loss of sensation but does not necessarily connote unconsciousness. Hence the application of a qualifying word in: local anesthesia, regional anesthesia, conductive anesthesia and spinal anesthesia. In many cases it is highly desirable to have unconsciousness in addition to analgesia. In a large number of cases, however, it is only necessary to have analgesia. Hence, the popularity of the various types of local anesthesia.

A patient's reaction to anesthesia and surgical intervention is the sum total of all stimuli that reach the brain. Surgeons are apt to minimize the effect of the emotional and psychic phenomena upon a patient about to undergo an operation. What is a commonplace experience to surgeons and hospital attendants is an adventure of terrifying and surprising magnitude to a great many patients. The preparation of the patient for operation, the preliminary hypodermic, the change of body apparel, the trip on a stretcher or chair from the patient's room to the operating amphitheater are all attended with disturbing and shock-producing impressions. It is true that the majority of patients discount the emotional effects that go with this surgical pageant but quite a number suffer severely and have a corresponding reaction which in many cases is out of all proportion to the surgical trauma inflicted in the operating room.

Sodium amytal when injected intravenously produces sleep in from four to six minutes, and simulates normal slumber so closely that, except for its being deeper, it is almost impossible to distinguish

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them. A larger dosage of sodium amytal intravenously administered induces a very definite and conclusive condition of analgesia. It has seemed to us that the sleep-producing possibilities of sodium amytal are superior and more to be desired than is the full analgesic effect. Sodium amytal and the supplemental use of ether, ethylene, nitrous oxide, spinal anesthesia, regional or local anesthesia, give a highly satisfactory and complete even anesthesia.

We have used sodium amytal alone or supplemented by other anesthetic agents in the following surgical conditions (Chart 1):

The effect of sodium amytal intravenously can be best indicated by describing a more or less typical case in which the drug is administered. The patient weighs 110 lb., has an hyperthyroidism of Graves' disease, with a basal metabolism of +80 and all the clinical signs of hyperthyroidism are present. The patient is marked nervous and emotionally agitated. She has been at rest in bed under proper preoperative treatment for a week. The operation is scheduled to begin at 8:30 A.M. On the day of the operation no breakfast is given, and at 8:15 A.M. the interne enters the patient's room and states that he is about to give her a treatment. A 10 per cent solution of sodium amytal is prepared and 100 mg. of the drug, or 1 c.c. of the 10 per cent solution is given every minute. After three and a half to four minutes the patient may state that she is becoming drowsy or becomes somewhat loquacious. At about four and a half minutes, the patient takes a deep sigh or yawns, and at about six minutes passes into a sleep. From six to nine minutes the breathing is rather shallow, the color good, the pulse about the same as at the beginning of the injection, although it may be somewhat slower. At about nine minutes the respirations increase in amplitude and the patient either snores or has the breathing typical of very deep slumber. The patient may or may not be roused but she is still sensitive to pain when the tissues are clipped with a towel clip. The

patient is allowed to remain at rest for another three to five minutes before being transported on a stretcher to the operating room. The patient is transferred to the operating table, elevated into the proper position, the field sterilized and draped. Before the operation is begun, the degree of analgesia is determined by pinching the skin. If the patient reacts, ethylene is then administered. In the majority of cases the ethylene may be discontinued or lightly administered during the remainder of the operation. At the conclusion of the operation the patient is returned to her bed and she sleeps anywhere from two to eight hours. In 80 per cent of the cases the patient gradually awakens as if after a quiet sleep. In about 20 per cent, of cases there is some increased irritability and restlessness. A sixth of a grain of morphine will adequately control this manifestation.

The instructions call for the giving of 1 c.c. of the solution containing 100 mg. per minute. Lately we have been giving it a little more slowly than this, feeling that we obtain a more gradual unconsciousness and that the analgesic properties are thereby increased. We have used sodium amytal with almost every variety of anesthetic agent and ether may be used after sodium amytal has been given without any preliminary state of excitement, pharyngeal distress or laryngospasm.

Such is the typical picture of the course of events after the intravenous administration of sodium amytal, irrespective as to whether the dosage is sufficient to produce complete analgesia or not.

Our patients as a rule have recovered or awakened from sodium amytal without restlessness. In only a few cases has it been necessary to give more than the usual postoperative injection of a sixth of a grain of morphine. The amytal apparently seems to work just as well without the preliminary morphine but we feel that the analgesic properties are enhanced by a preliminary injection of a sixth of a grain of morphine fifteen to twenty minutes before the expected time of operation.

TABLE I

Name	Sex	Chart No.	Weight	Age	Surgery	Amytal Amt. Administered (Gram)	Time for Complete Unconsciousness (Minutes)	Analgesia	Supplemental Anesthesia	Recovery	Comment
G. W.	F.	53621	141	19	Thyroidectomy Graves' disease	1.0	7	...	Ethylene	Quiet	B.M. + 48
I. G.	M.	50848	112	54	Gastroenterostomy	1.0	5.5	+	.....	Quiet	
C. Z. S.	M.	51136	149	48	Cholecystectomy Appendectomy	1.0	6.5	+	Ether*	Quiet	
F. S.	M.	51559	126	18	Thyroidectomy Graves' disease	1.0	6	...	Ethylene	Restless	B.M. + 71
S. S.	F.	51639	128	27	Thyroidectomy Graves' disease	1.0	6	...	Ethylene	Restless	B.M. + 58
H. G.	F.	51648	100	33	Thyroidectomy Adenoma—hyperthyroidism	1.0	6.5	...	Ethylene	Quiet	B.M. + 38
S. T.	F.	52074	118	65	Thyroidectomy Carcinoma of thyroid	1.2	2	+	.....	Quiet	B.M. + 28
S. P.	F.	52587	114	18	Thyroidectomy Graves' disease	0.8	4.5	...	Ethylene	Quiet	B.M. + 58
A. P.	M.	52601	119	21	Thyroidectomy Graves' disease	1.0	8	...	Ethylene	Quiet	B.M. + 68
G. S.	M.	53158	128	41	Thyroidectomy	1.0	...	...	Ethylene	Restless	B.M. + 68
H. B.	F.	53148	94	21	Thyroidectomy Graves' disease	0.9	6	...	Ethylene	Quiet	B.M. + 68
E. S.	F.	53804	39	39	Thyroidectomy Adenoma of thyroid	1.0	6	...	Ethylene	Quiet	Congenital heart disease
T. G.	F.	53887	140	38	Thyroidectomy Adenoma of thyroid	1.0	8	+	Ethylene*	Restless	B.M. + 30
C. McK.	F.	54079	100	65	Thyroidectomy Adenoma of thyroid	0.8	5	...	Ethylene	Quiet	Asthenia
E. D.	F.	54055	116	40	Cholecystectomy Appendectomy	0.9	4.5	...	Ethylene*	Quiet	Pulmonary tuberculosis
J. W.	M.	54307	109	46	Thyroidectomy Graves' disease	1.0	6	...	Ethylene	Quiet	B.M. + 48
F. V.	F.	54292	82	16	Thyroidectomy Graves' Disease	0.9	8	+	Ethylene*	Quiet	B.M. +
E. H.	F.	54396	112	43	Laparotomy Perineorrhaphy	0.7	4	+	.....	Quiet	
E. F.	F.	54299	114	52	Thyroidectomy Adenoma of thyroid	0.9	5	+	Ethylene*	Quiet	B.M. +
W. D.	M.	54588	156	42	Herniotomy	0.7	6	...	Nitrous oxide	Quiet	
F. S.†	M.	54249	126	18	Thyroid crisis of Graves' disease No surgery	0.8	6	Slept 10 hours	.....	Quiet	Complete relaxation and rest obtained

\* Supplemental anesthesia only necessary at beginning or end of operation.

† Used to produce unconsciousness in a patient verging on thyroïdal delirium.

TABLE 1 (Continued)

Name	Sex	Chart No.	Weight	Age	Surgery	Amytal Amt. Administered (Gram)	Time for Complete Unconsciousness (Minutes)	Analgesia	Supplemental Anesthesia	Recovery	Comment
J. W.	F.	54429	148	28	Thyroidectomy Adenoma of thyroid	0.9	5	...	Ethylene	Quiet	B.M. +
C. M.	F.	54020	114	36	Hysterectomy Salpingectomy	0.7	4	...	Ether	Quiet	Anemia
L. M.	F.	54413	105	57	Appendectomy	0.9	...	+	.....	Quiet	
D. P.	F.	54804	120	33	Curettage	0.7	...	+	.....	Quiet	
J. W.	F.	54429	148	28	Tonsillectomy	0.8	...	...	Ether	Restless	
A. P.	F.	54796	110	48	Resection of sigmoid	0.9	...	...	Spinal	Quiet	
P. J.	F.	.....	112	42	Cholecystectomy	0.9	...	...	Nitrous oxide	Quiet	
M. J.	F.	54512	110	42	Excision of thrombotic vein, leg	0.7	...	...	Ethylene	Quiet	
J. P.	F.	54649	128	45	Thyroidectomy Adenoma of thyroid	0.7	5	...	Ethylene	Quiet	
E. C.	F.	54663	102	51	Salpingo-oophorectomy Resection of intestine	0.9	...	...	Ethylene	Quiet	
M. T.	F.	54641	103	31	Thyroidectomy Graves' disease	0.9	...	...	Ethylene	Quiet	B.M. + 81 and + 84
M. T.*	F.	54758	125	58	Thyroidectomy Adenoma of thyroid	0.9	...	...	Ethylene	Quiet	
G. R.	F.	54921	129	37	Thyroidectomy Graves' disease	0.7	2	...	Ethylene	Quiet	B.M. + 78
S. F.	F.	55225	125	55	Subhepatic abscess Cholecystectomy	0.5	5	...	Ethylene	Quiet	Possible metastatic carcinoma

\* Weak, asthenic chronic cardiac, chronic hyperthyroidism: had prolonged unconsciousness after thyroidectomy.

From a few patients we have taken a sample of blood just before giving the sodium amyral and a second sample of blood one hour after the administration of the sodium amyral and in the chemical examination of the blood have found only slight metabolic changes. There is a small transient rise in the amount of blood sugar.

If a full calculated dose of sodium amyral is given the patients do require more post-operative nursing care than after other anesthetics. There is a slight tendency for increased pharyngeal relaxation with

swallowing of the tongue. In one case, a very asthenic, frail, cardiac case, with fibrillation secondary to chronic hyperthyroidism, our patient did have a prolonged post-operation sleep. She could be awakened, could be made to take fluids, but would doze off again and the condition was not unlike hibernation. Respirations were quiet, pulse was uniform, patient turned occasionally but was almost completely unconscious. This condition was not alarming as we were able to give fluids by passing a Levine tube through the

nose and carried on adequate alimentation for the better part of twenty-four hours.

We have made it a rule not to tell the patient the action of the drug. This is particularly true for our goiter work. At the beginning of the preoperative treatment for hyperthyroidism we quite frankly discuss the condition with the patient and tell her that we will operate when in our judgment we have obtained the maximum benefit from our treatment. Since the patient has omitted breakfast before it does not occasion much apprehension in her mind to omit a breakfast on a particular morning and with a sort of casual indifference the surgeon gives an intravenous injection of sodium amytal. This is always done in the patient's room and when the patient awakens she has no memory for the events from the time of the injection was made until she awakens.

The combination of sodium amytal and ethylene has given excellent results both in goiter and in abdominal surgery. In the latter the amount of relaxation has been quite sufficient and has allowed us to do most of the intra-abdominal procedures with the same facility and ease as with ether.

We have therefore employed sodium amytal for the following reasons: (1) its psychological effect; the administration of sodium amytal intravenously is simplicity itself; it does produce total unconsciousness with loss of memory for all events between the time of injection to the time of awakening after operation. (2) Its physiological effect: the postoperative course in patients who have had sodium amytal intravenously has been on the whole quieter, with less reaction, irrespective as to whether ethylene, nitrous oxide, ether or spinal anesthesia has been employed in addition. (3) Its synergistic effect in that it lessens the amount of supplemental anesthesia if it is necessary to employ one.

The preliminary intravenous administration of sodium amytal plus ethylene gives a more complete abdominal relaxation than is possible with ethylene alone

or with ethylene plus morphine and scopolamine. When nitrous oxide is employed, with a preliminary intravenous sodium amytal the amount of gas used is less, the anesthesia more even and less likelihood of the patient "coming out." When employed with ether the amount of ether used is much less and the evenness of anesthesia is more adequately maintained.

In this small series we have on a few occasions increased the dosage and obtained excellent analgesia as is indicated in the laparotomy for cholecystectomy and the laparotomy for gastroenterostomy, when no supplemental anesthetic agent was used. It is interesting to note that not all patients give the same degree of unconsciousness or the same degree of analgesia. Some individuals are more susceptible to the action of sodium amytal intravenously than others. For example, one patient permitted a laparotomy without any pain sense and yet occasionally mumbled during the operation. Other cases were rendered unconscious rather readily but did not have as pronounced an analgesia as others. Increasing experience has made it seem less desirable to produce complete analgesia by means of sodium amytal as the combination of amytal plus ethylene is so highly satisfactory that purely for personal reasons I have not been desirous of seeing how far I could go in the production of analgesia by increasing the dosage of sodium amytal. Our experience would seem to suggest the following surgical indications for its use: (1) hyperthyroidism of either the Graves' disease or adenoma type; (2) laparotomies in which it is desirable to have relaxation with ethylene; (3) perineal and analperineal operations with sodium amytal alone or added to nitrous oxide or ethylene; (4) kidney operations under sodium amytal and ethylene; (5) to produce unconsciousness wherever there is an emotional element of any degree incident to the trip to the operating room, regardless of the type of operation; (6) for the control of postoperative delirium or excitement; (7) as a preliminary measure



to promote rest, preoperatively, in highly toxic goiter cases, (8) in any condition where it is desirable to produce complete unconsciousness and restful sleep for six to twelve hours.

Since the preparation of this paper 25 additional cases of the same general character have been operated upon under intravenous sodium amytal.

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## A NEW CYSTOSCOPE CORD\*

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MAX NITZE in 1879 presented to the profession a cystoscope which has been modified by Brenner, Brown, Albarran, Lewis, Kollman, Kelly, Cullen, Buerger, Braasch, McCarthy, Young and others. With the improvement of the instrument and the technic in its use, urology has become an exact science.

During the past five years, while studying the bacteriology of the upper urinary tract, I have found it impossible to use a technic that was aseptic and practical, there being a constant danger of breaking the technic from the use of a cord that could not be boiled or sterilized in an antiseptic solution. With a desire to rectify the source of danger, I requested the American Cystoscope Makers, Inc. to make a cystoscope cord that could be boiled or sterilized in chemical solutions.

Through the cooperation of W. H. Dodge and C. C. Steffek, the following cord was made (Fig. 1).

The rubber composition of the cord is such that it is made to withstand the various chemical actions during sterilization and the electrical contact is heavily insulated with vulcanized rubber with an on-and-off switch at contact to eliminate the possible corrosion at the switch.

This cord has been used routinely for the past two months, being sterilized by

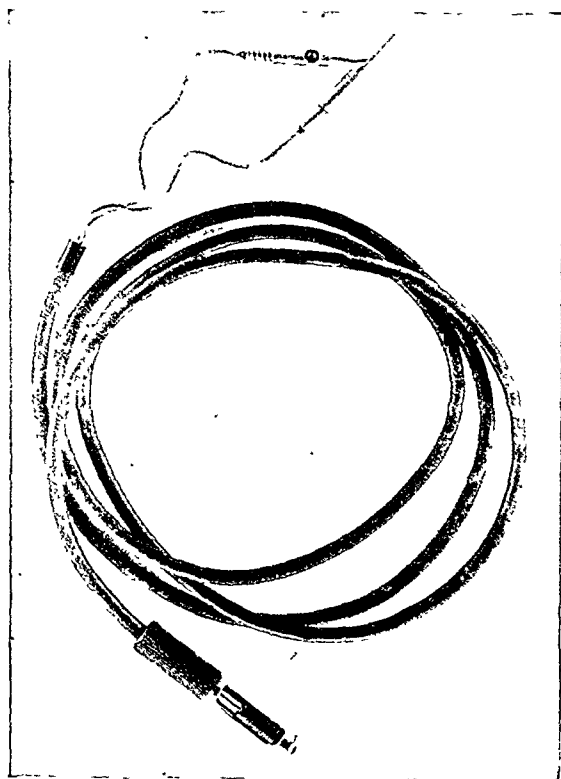


FIG. 1.

boiling or in mercuric iodide solution, with all control cultures being negative.

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# PHARMACOLOGICAL ACTION OF SODIUM AMYTAL; INCLUDING A STUDY OF ITS EFFECTS UPON RESPIRATION AND CIRCULATION IN RELATION TO LOCAL, REGIONAL, AND GENERAL ANESTHESIA\*

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A GENERAL experimental and clinical discussion of the pharmacological action of sodium amytal may be conveniently divided into three parts, with further subdivision as follows:

- I. General Pharmacological Actions.
  1. Metabolism
  2. Central Nervous System and Smooth Muscle
  3. Circulatory System
  4. Respiratory System
- II. The Effects of Sodium Amytal in Relation to Untoward Reactions Following the Use of Local Anesthetics.
- III. The Minute Volume of Respiration; Blood Pressure and Pulse. Effects of Combinations of Sodium Amytal, Morphine, Scopolamine, Ether and Carbon Dioxide.

## I. GENERAL PHARMACOLOGICAL ACTIONS

*Effects on Metabolism.* Amytal was introduced by Page<sup>1</sup> in 1923 as a laboratory anesthetic. He stated that it was capable of maintaining satisfactory anesthesia without producing hyperglycemia. Also, that its action was unaccompanied by associated generalized inhibition of carbohydrate metabolism as indicated by the fact that hyperglycemia was obtained under amytal anesthesia upon splanchnic stimulation or severe hemorrhage, and insulin still produced hypoglycemia unaccompanied by convulsions. Hepburn, Latchford, McCormick, and Macleod,<sup>2</sup> Britton,<sup>3</sup> Markowitz,<sup>4</sup> and Collens,<sup>5</sup> have found normal or slightly subnormal values for blood sugar after amytal administration. Deuel, Chambers and Milhorat,<sup>6</sup> also observed that after intraperitoneal injection of amytal in doses of 50 to 75 mg. for each kilogram of weight in normal

fasting dogs, no change in blood sugar level occurred in periods as long as six to eight hours after injection. However, Weiss<sup>7</sup> reported that amytal anesthesia in cats induced an increase in the blood sugar level of 100 to 250 per cent above the fasting level, and in dogs, one of 80 to 150 per cent. The maximal values of the blood sugars were obtained one to two hours after the injection of the amytal, and the hyperglycemia persisted from six to twenty hours. Underhill and Sprunt<sup>8</sup> found that in a series of 10 experiments on rabbits, 8 gave evidence of distinct hyperglycemia, which usually appeared within an hour, or somewhat later, and in some cases lasted for several hours. These results followed doses ranging from 50 to 100 mg. for each kilogram, of amytal, whether given by mouth, subcutaneously or intraperitoneally. Hines, Boyd and Leese,<sup>9</sup> in 1926, stated that amytal anesthesia lessened the ability of an animal to handle glucose when injected by the continuous intravenous method. This was indicated by increased hyperglycemia and glycosuria, associated with slight lowering of the plasma pH. A comparison of glycogen formation in the unanesthetized and anesthetized (amytal) animal was made in experiments on dogs by Hines, Leese and Barer,<sup>10</sup> in 1928. It was found that approximately the same increase in muscle glycogen occurred in animals with or without amytal anesthesia. However, the increase in liver glycogen was over twice as great in the unanesthetized animal as in the experiments in which the glucose injections were made under amytal anesthesia.

Metabolic changes in patients after sodium amytal anesthesia were reported

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by Zerfas and McCallum<sup>11</sup> in 1929. They observed that examinations of the urine following administration of the drug were essentially negative except for excessive amounts of urates for twenty-four hours postoperatively. The carbon-dioxide combining power showed no appreciable change during the anesthetic stage. A slight drop in non-protein nitrogen occurred for a day or two postoperatively, but was within normal limits. The blood sugar level showed a tendency to increase, but rarely exceeded the minimal normal limits unless there was a previous metabolic disturbance.

The basal metabolism was studied by Deuel, Chambers and Milhorat,<sup>6</sup> 1926. They found it to be slightly lowered after amytal, but it usually remained at a constant level despite a fall in body temperature of two or three degrees. They observed narcosis in normal fasting dogs coming on rapidly after the intraperitoneal injection of amytal, the average length of time necessary for its development being about seven minutes. The fall in body temperature after amytal was rapid, reaching a minimal value usually three to four hours after the amytal administration, at which level it was observed to remain approximately constant for three to four hours in case no shivering occurred. When shivering appeared, the metabolism in some instances was doubled.

*Effects on Central Nervous System and Smooth Muscle.* Mason and Baker,<sup>12</sup> 1930, have given a complete account of the early effects of sodium amytal on the central nervous system in patients. Their description is as follows:

The induction of sleep is rapid and quiet, almost dramatic. During the intravenous administration of the first 3 to 9 grains, the patient may remark that he is feeling sleepy, and if engaged in conversation he begins to slur his words; finally he may yawn, and drop off into a quiet sleep in the middle of a sentence, while the drug is still being given.

As the dose was increased they observed the patient to become reflexly hypersensitive and finally to enter a profound state

of anesthesia. The pupils became contracted and in some cases fixed so that they would not react to light. The corneal wink reflex was diminished. The gag reflex was usually present. The knee jerks were often exaggerated during the period of hyperesthesia, but could still be elicited with the deeper degrees of anesthesia secured by larger doses.

This preservation in some cases of the reflex responsiveness is held as an advantage, since it is theorized that the patient can better react to stimulation. On the other hand, the persistence of these reflexes may tend to disprove the induction of complete anesthesia with protection against surgical shock to the nervous system.

The postoperative course of patients anesthetized with sodium amytal has been accurately described by Zerfas and McCallum,<sup>13</sup> 1929.

When the drug was sufficiently eliminated or oxidized, the patients passed through a mildly restless period which as a rule preceded the regaining of consciousness. During the restless stage, which was of comparatively short duration, the patients tossed their arms aimlessly about, and often attempted to move in an uncoordinated fashion, but not violently. Occasionally they uttered incoherent statements. It has been our experience that the administration of small doses of morphine at this time has been sufficient to keep the patient quiet until full consciousness was regained. Some patients aroused clearly from their sleep without any period of restlessness. After consciousness was regained, they were drowsy and continued to sleep at intervals for two or three days, but their cooperation was readily attained for the administration of fluids and so forth. Very often patients did not remember incidents and conversation that occurred during this time, although they apparently were conscious. Nausea, retching and vomiting occurred in only one instance, and was thought to be due to a sensitivity to morphine.

It is of interest to consider the analagous effects of related barbituric acid compounds on the nervous system, and to inquire into the possible mechanisms by which the

effects are brought about. By attempting to localize the actions of powerful drugs one is better able to antidote those actions or to supplement them by combinations with other similarly acting compounds. After extensive clinical and experimental study of the barbituric acid derivatives, Weiss<sup>14</sup> came to the following conclusions:

Man is more susceptible to barbituric acid derivatives than animals, and marked individual variations exist in the response of patients to identical doses. The state of the central nervous system is one of the important factors which determines the variations in the intensity of effect, and in the persistence of action. Sensory and motor excitement act antagonistically, while depression acts synergistically with the barbituric acid derivatives. The dose administered to a patient should be determined by the individual behavior of the subject during the slow intravenous administration of the hypnotic. The mechanism of the action of the barbituric acid derivatives is different from that of ether, chloroform and nitrous oxide. These anesthetics usually cannot be replaced by the barbituric acid derivatives. The latter have marked inhibitory influence on certain medullary and mid-brain centers.

There is some evidence to suggest that barbiturate action is most selective for the hypothalamic portion of the diencephalon. Some investigators have held that important vegetative centers including a so-called sleep center, are found in this region. This hypothesis helps to explain the limited usefulness of caffeine in overcoming the effects of large doses of barbituric acid derivatives. Likewise, the potentiating effect of morphine upon the action of the barbiturates is more easily understood. Both caffeine and morphine are considered to have marked cortical action, whereas the action of the barbiturates is apparently largely subcortical.

At this point attention should be called to the very interesting work on labyrinthine and postural reflexes by R. Magnus,<sup>15</sup> reported in 1926. He pointed out in preceding articles that these complicated reflexes were mediated to a large extent

through nuclei in the brain stem, and showed that it was possible by investigating a great number of postural and labyrinthine reflexes to measure quantitatively the stimulant and depressing action of drugs upon the central nervous system. He described experiments on rabbits on the action of a combination of veronal and pyramidon known as veramon. In veramon the stimulating action of pyramidon was completely neutralized by veronal, and on the other hand, by pyramidon, the depressing action of the veronal was, according to the dose given, either strongly delayed, greatly diminished or completely neutralized. It is suggested here that pyramidon stimulates more nearly the centers depressed by the barbiturates than most of the other central nervous system stimulants, and hence, might prove to be of some value therapeutically after intense barbiturate action. The neutralizing effects of the barbiturates upon the local anesthetics of the cocaine group of central origin, are probably based on a similar localization of action.

The anti-convulsant properties of the barbituric acid derivatives have been found to be very distinct; thus in patients with severe status epilepticus, strychnine poisoning, grave toxic reaction from local anesthesia, convulsions due to cerebral hemorrhage, eclampsia and tetanus, the intravenous administration of barbituric acid derivatives is of definite therapeutic value.

*Smooth Muscle.* Kymographic records of the contractions of the uteri of virgin guinea pigs were made by Drabkin, Ravdin, Hirst and Lapham,<sup>16</sup> 1929. In some cases the uteri were studied in situ, in animals anesthetized with large doses of amytal. In other cases one cornu of the uterus was removed and studied in a constant temperature bath to which high concentrations of amytal were added. In all cases the rhythmic contractions were maintained under the anesthetic. The response of the uteri to the oxytocic principle of the pituitary was not disturbed after amytal anesthesia.

Zerfas and McCallum<sup>11</sup> measured the effects of sodium amytal on uterine contractions of patients in labor by the use of a mercury manometer which was connected to a Voorhees bag inserted into the cervix. In this manner the contractions were recorded. Doses up to 0.018 gm. or one-third grain for each kilogram were given within two hours without affecting the force, duration or frequency of uterine contractions.

Judging from the actions of barbituric acid derivatives closely related to sodium amytal, one would infer that these compounds were without marked action upon smooth muscle. Thus Jackson<sup>17</sup> in 1922, showed that isopropylethyl barbituric acid did not cause broncho-constriction in dogs so far as its direct action on the bronchioles was concerned. He also stated that the stomach and intestines were almost entirely uninfluenced by ordinary doses of this compound.

*The Circulatory System.* A careful study of the pharmacological actions of isopropylethyl barbituric acid was made by Jackson<sup>17</sup> in 1922. One cannot assume that the actions of closely related barbituric acid derivatives are identical, but it is safe to conclude that they are analogous and comparable to a certain degree. Writing on isopropylethyl barbituric acid, Jackson pointed out that with small doses, the blood pressure showed a slight fall that was both insignificant and temporary. The heart beat was but little affected by the drug when therapeutic doses were injected suddenly directly into the circulation. He concluded that the heart was entirely outside the sphere of action of the drug when given in any such quantities as would be used medicinally. The vagus inhibitory mechanism was entirely unaffected by the drug.

In experiments on dogs, rabbits and cats, Lieb and Mulinos,<sup>18</sup> 1929, found a temporary (one and one-half to two hours) paralysis of the vagus inhibitory mechanism of the heart, as a result of the administration of isoamylethyl barbituric acid.

Edwards and Page,<sup>19</sup> in 1924, showed that experimentally, sodium amytal was without effect on the circulatory system, a well-sustained blood pressure with little change in the heart rate, and no alteration in dynamic capacity of the heart being noted. According to Drabkin and Edwards,<sup>20</sup> this hypnotic is without effect on blood concentration.

The coronary circulation was studied by Gruber and Roberts,<sup>21</sup> in 1926. All the barbituric acid derivatives tested, including barbital, luminal, sodium luminal, amytal and somnifene, in dilute solutions, produced coronary vasodilatation when introduced into the perfusion fluid of an isolated cat or rabbit heart. Concentrated solutions produced variable results, but these were believed to be due in part, if not wholly, to the change in the pH of the perfusion fluid.

Many observations on patients have been made by Zerfas and McCallum.<sup>13</sup> They noted a variable response in the pulse rate during and shortly after the completion of the injections of sodium amytal. Usually the rate was increased; it was very seldom decreased, and often was unchanged from normal. The blood pressure practically always decreased during the time of injection, but usually returned to its previous level within a few minutes. These observations have been quite generally confirmed, as is indicated by the report of Mason and Baker.<sup>12</sup> In their patients the pulse rate, if elevated by emotional excitement, was reduced during the induction of anesthesia. In all other cases, however, the pulse appreciably quickened after injection of the sodium amytal, an average of + 15 beats per minute. The blood pressure, in all but a few instances fell, the systolic an average of 30 mm. of mercury, and the diastolic an average of 15 mm., during the induction of anesthesia, but returned to the normal level early in the operation or else was restored to normal by the administration of ephedrine.

The moderate acceleration of the pulse described is probably due, in part, to

temporary vagus inhibition. The fall in blood pressure appears to be anaphylactoid in origin, in common with the circulatory response seen after intravenous injection of solutions of many drugs. It has been our observation that the more dilute the sodium amytal solutions and the more slowly it is injected, the less apparent are the vasodilator effects.

*The Respiratory System.* Attention is again called to the work of Jackson<sup>17</sup> on the analogous barbituric acid derivative, isopropylethyl barbituric acid. He stated that with moderate doses the respiration and circulation appeared to be practically uninfluenced by the drug. After very large doses, a considerable increase in the depth of respiration was seen, as the respiration became progressively slower. Respiratory depression became more and more evident with increasing doses, and was the final cause of death in fatal cases. With care, the animal could be repeatedly revived after the respiration ceased, thus showing that artificial respiration was the chief remedy needed in case of severe poisoning with the drug. Jackson observed that it was often very advantageous in experimental work to give one or two fairly large injections of the isopropylethyl barbituric acid, to quiet an animal which did not take ether well, but continued to breathe rapidly and irregularly, and to have slight convulsive seizures, but in which a slight excess of ether tended to stop the respiration or greatly lower the blood pressure. In such animals, the reflexes could be quieted and the animal reduced to a calm and satisfactory condition, by two or three fair-sized injections of the drug. The ether could then be continued without further difficulty.

In 1926, Page and Coryllos<sup>22</sup> described the effects of sodium amytal on the respiration as follows:

In general, the respiration is decreased in rate, and slightly, in amplitude, with increasing dosage. Just before death the rate increases, and certain irregularities are at times observed in the animals under very deep anesthesia. It

is not uncommon to find a series of three respiratory movements alternating with prolonged pauses. That the respiratory center is still responsive, may be demonstrated by pressure on the thorax producing the suffocation reflex. Such a procedure immediately increases the rate of respiration two to threefold.

They recommended for dogs, a dosage of 45–60 mg. for each kilogram as being most suitable for ordinary experimental procedures. With this optimum dosage, they found the circulation and respiration well maintained over a wide range of surgical procedures.

Clinical descriptions of the respiratory changes, following intravenous injections of sodium amytal, have been reported by Zervas and McCallum.<sup>13</sup> They stated that the respirations following loss of consciousness, were usually decreased in amplitude, were regular, and were more apt to be slightly increased in rate, though frequently they remained normal. There was little change in the color of the skin, although occasionally a slight degree of cyanosis was present. In a few patients, considerable blanching of the skin occurred. In the majority of instances, however, the color of the skin remained unchanged. When ether, nitrous oxide and oxygen, ethylene, or a mixture of carbon dioxide and oxygen were given, both the amplitude and rate of respiration increased.

Mason and Baker<sup>12</sup> observed the respiration to become shallow, with a slight increase in the rate. In a few cases, the respiratory rate, however, fell as low as 12 per minute. The color in all but a few cases remained uniformly good. In all their surgical cases, morphine sulphate  $\frac{1}{16}$  to  $\frac{1}{4}$  grain with atropine sulphate  $\frac{1}{150}$  grain was given one hour prior to the administration of the sodium amytal.

## II. THE EFFECTS OF SODIUM AMYTAL AND ARTIFICIAL RESPIRATION IN EXPERIMENTAL NOVOCAINE POISONING

Since the introduction of cocaine into surgical practice as an anesthetic, many

instances of toxic action of the drug have been observed. Accordingly, numerous substitutes for cocaine have appeared with the idea of avoiding the undesirable effects of local anesthetics. As a substitute for cocaine, novocaine or procaine has found the most extensive use.

Other approaches to the problem are being made. More attention is being given to the doses of the local anesthetics administered, and particularly to the concentrations of the solutions used. Furthermore, the method and speed of injection, and the temperature of the solutions have come to be recognized as factors of great importance. Nevertheless, in many instances, careful attention to the details of administration of the local anesthetics does not eliminate entirely the possibility of objectionable reaction.

Experience has demonstrated that novocaine is less toxic than cocaine, only when certain conditions prevail. According to Eggleston and Hatcher,<sup>23</sup> 1916:

One is not justified in speaking of ratio of toxicity of novocaine and cocaine, without reference to the mode and rate of administration, the concentration of the solution used, and the species of animal employed. Novocaine is safer than cocaine only when it is used properly, special attention being given to the heart and respiration, and avoidance of rapid entrance of the drug into the circulation.

More recently Lundy,<sup>24</sup> in 1927, and McCuskey<sup>25</sup>, in 1928, have presented an abundance of clinical evidence in accord with the opinions of Hatcher and Eggleston.

Further investigation of the origin of the untoward reactions seen clinically following cocaine and novocaine injections would seem to be important. Consideration also should be given to the possibility of counteracting and preventing the ill effects of local anesthetics by the use of other drugs and procedures, which have an antagonistic action.

Prevention of convulsions and the fatal result of ordinarily lethal doses of cocaine by the use of barbitol, was described

by Hofvendahl,<sup>26</sup> in 1921. An important series of results was obtained by Tatum, Atkinson and Collins,<sup>27</sup> in 1925. They were able to increase the tolerance of animals to cocaine by the use of artificial respiration, but more particularly by the administration of barbitol combined with paraldehyde. The convulsions seen in cocaine poisoning appeared to be especially detrimental. The survival of the animal often appeared to depend upon their severity and duration. Barbitol and paraldehyde were shown to be highly effective in removing those convulsions. Knoefel, Herwick and Loevenhart,<sup>28</sup> 1928, stated that sodium amytal was much more efficient than barbitol in preventing fatal outcome from cocaine injections in rabbits. Magnesium sulphate, on the other hand, though a powerful depressant, rendered animals much more susceptible to novocaine and cocaine.

Following these observations, clinical reports appeared, indicating the possible value of the barbiturates as preventives of untoward reactions due to local anesthetics. Leshure,<sup>29</sup> 1927, reported that while morphine alone, or combined with scopolamine, did not prevent the occasional toxic reactions due to local anesthetics, from 0.4 to 0.8 gm. of sodium veronal administered by mouth routinely before operative procedures with a local anesthetic, was efficient to prevent toxic reactions.

Williams,<sup>30</sup> 1927, used 0.3 gm. of barbitol two hours and one hour before the beginning of operations with local anesthetics. He also noted beneficial results. It was observed by Martin,<sup>31</sup> 1928, that the frequency and severity of toxic reactions due to novocaine were considerably reduced in patients receiving 0.60 gm. of barbitol the night before, and one hour before the surgical operation. Also, Guttman,<sup>32</sup> 1928, stated that the routine hypodermic administration of from 0.18 to 0.3 gm. of barbitol, reduced the frequency of toxic reactions following the use of novocaine. Lundy,<sup>33</sup> 1929, reported that preliminary medication with sodium

amytal, in most instances combined with small doses of morphine, established a good mental attitude in the patient toward local anesthesia. No convulsions appeared, nor was operation postponed in any instance because of nausea and vomiting. He felt that the barbiturate protected the patients against untoward effects of unintentional intravenous injection of novocaine, in addition to producing hypnosis.

At the suggestion of Dr. Lundy and Dr. Rowntree, an experimental and clinical study of the nature and extent of the antagonism existing between the actions of novocaine and sodium amytal was made by Dr. Lundy and myself at the Mayo Clinic.

It was observed that novocaine in overdoses in patients was succeeded by the following phenomena: fall in blood pressure, usually a slow pulse, shallow breathing, pallor and cyanosis, sweating, sometimes nausea and vomiting, and occasionally mental confusion and apprehension. In one or two instances, convulsions, preceded by great anxiety and followed by depression, had been observed. Many of the same effects of the novocaine were evident in the experiments on dogs which follow:

*Method.* Local or spinal anesthesia was used to prepare dogs for records of respiration from the trachea, and of blood pressure from the femoral artery. The respiration was recorded by means of a membrane manometer, and the blood pressure by the use of a mercury manometer. Twelve major experiments were performed.

*Results.* 1. After a definitely hypnotic dose of the sodium salt of isoamylethyl barbituric acid had been administered, novocaine injected intravenously in repeated doses of a 20 per cent solution, and averaging about 200 mg. for each animal at each injection, produced its characteristic fall in blood pressure accompanied by decline in rate and depth of breathing. The presence of the sodium amytal did not seem to intensify the effects of novocaine observed in control

experiments without the preliminary administration of the amytal. (Graphs No. 3 and 4.)

2. After isoamylethyl barbituric acid had been administered, convulsions did not appear when novocaine was administered intravenously, either by slow injection of a 1 per cent solution, or by injection of the animal with repeated doses of 20 per cent solution, each dose of which contained 200 mg. of novocaine. (Graphs No. 2, 3, and 4.)

3. The fall in blood pressure in animals, after adequate doses of novocaine had been given intravenously, closely paralleled and coincided with the respiratory depression. (Graphs 3 and 4.)

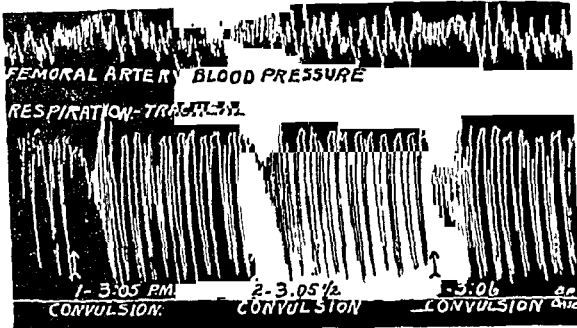
4. After complete respiratory paralysis had resulted from the intravenous administration of novocaine, the circulatory system almost always maintained its functions, though depressed, without support of circulatory stimulants for long periods. During this interval, adequate and properly administered artificial respiration was given. This period was characterized in the majority of cases, by prompt recovery in the level of the blood pressure, and usually later by recovery of the function of respiration. Respiratory paralysis from injections of novocaine into the spinal fluid responded equally well to mechanical ventilation. In one experiment of this type, the respiration was paralyzed completely for ten hours by a large intraspinal injection of novocaine. Mechanical ventilation alone was adequate to sustain the animal until recovery, with only a slightly subnormal blood pressure. This animal's spinal cord later showed marked evidence of degeneration as a result of the highly concentrated and excessive amount of novocaine. Twenty-five hundred milligrams of the drug in 50 per cent solution were introduced into the lumbar region of the spinal canal. (Graphs 3 and 4.)

5. In several instances, impairment or paralysis of the intercostal muscles, with the diaphragm still functioning well, following the administration of novocaine, intra-



venously or intraspinally, was accompanied by a low blood pressure. Artificial respiration applied to these animals resulted in

had been effective in those animals in which respiratory paralysis had been produced by novocaine, but in which convul-



GRAPH 1. Dog No. 1. Wt. 11.75 kg. 9-27-28.

Anesthesia: Quinine urea hydrochloride 0.5 c.c. of 50 per cent, spinal. One-half per cent novocaine local for introduction of tracheal cannula.

2:55 P.M. 50 c.c. of 1 per cent novocaine by continuous intravenous injection, 20 c.c. per minute.

3:00 17 c.c. of 1 per cent novocaine continuous intravenous injection, 20 c.c. per minute.

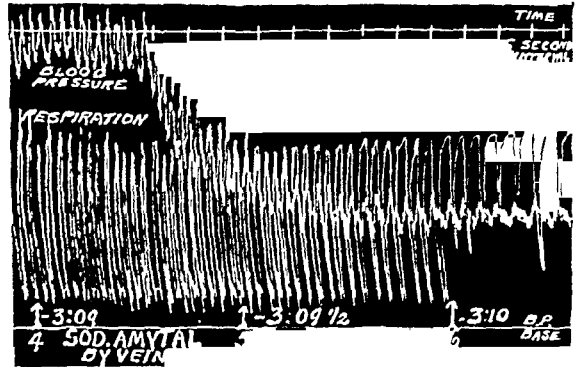
3:05 (1) Convulsion.

3:05 1/2 (2) Convulsion.

3:06 (3) Convulsion.

distinct elevation of the blood pressure to the control level.

6. Convulsions were induced in animals by slow intravenous injection of 1 per cent novocaine. The sodium salt of isoamylethyl barbituric acid, given intravenously, stopped the convulsions immediately and rendered the animals stuporous and relaxed. There was considerable drop in blood pressure accompanied by impaired respiration for from ten to twenty minutes after large intravenous doses of sodium amytal had been given in the presence of convulsions caused by novocaine. During the convulsions there was a definite spastic paralysis of respiration, in the expiratory position, with each seizure. The blood pressure declined rapidly after the convulsions became frequent, intense and prolonged, and the respiratory exchange became definitely incomplete. After prolonged and frequent convulsions exhaustion appeared rapidly, respiration ceased and the blood pressure fell abruptly. At this time artificial respiration seemed to be lacking in supporting effect, although it



GRAPH 2. Dog No. 1. 9-27-28.

3:09 to 3:09 1/2 (4 to 5) Injection by vein of 3.6 c.c. of 10 per cent sodium amytal. (Total of 360 mg. or 30 mg. per kilo).

3:10 (6) Definite fall in blood pressure to horizontal level. Definite slowing of respiratory rate and decrease in amplitude.

sions had been prevented by the use of sodium amytal. (Graphs 1, 2, 3, and 4.)

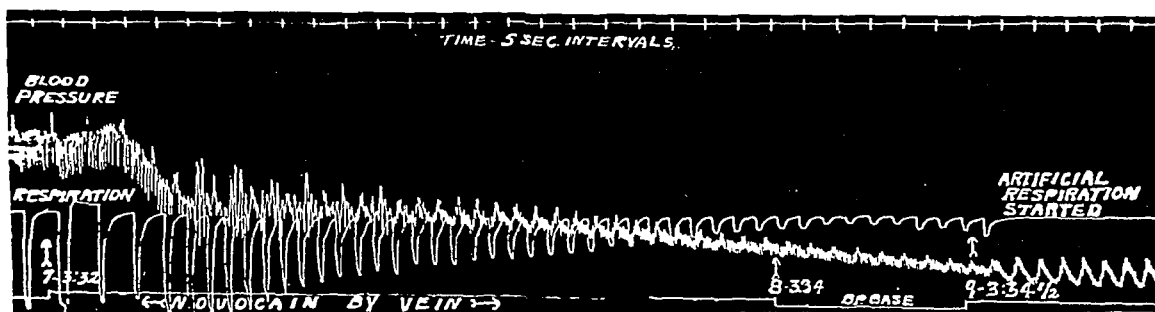
**Discussion.** These results place additional emphasis on the respiratory factor in depression from local anesthetics, and the close correlation between circulatory and respiratory depression, after toxic doses of novocaine were given intravenously to dogs, suggests a causal relationship between the two phenomena. (Graph 3.) This is also indicated by the pressor effect often seen when adequate ventilation is provided in the presence of novocaine depression. (Graphs 3 and 4.)

Similarly, oxygen administration and artificial respiration applied to animals and patients, in the presence of low blood pressure and diaphragmatic breathing after intraspinal novocaine, as described in section five of the results, have been observed to be of definite value in raising the blood pressure. The beneficial effect here may be due to relief of existing anoxemia as a result of incomplete pulmonary ventilation, or may provide additional mechanical assistance to the return flow of blood to the heart.

In view of the need for adequate pulmo-

nary ventilation in novocaine poisoning, the value of the barbiturates in controlling the convulsions is enhanced.

fall in blood pressure, with a closely paralleled depression in respiration, ending in respiratory paralysis. Hence, at (9) the



GRAPH 3. Dog No. 1. 9-27-28.

3:32 to 3:34 (7 to 8) Injection by vein of 30 c.c. of 1 per cent novocaine.  
3:34½ (9) Artificial respiration started.

*Discussion of Graph 1:* The convulsions shown are three of a series of ten produced in the animal by the intravenous novocaine. Note the rapid, deep respiration with fixation of the chest in the expiratory position during the spasms. The convulsions were very violent and were recurring at half-minute intervals. The blood pressure had not begun to decline. The animal was in a marked stage of mental and motor excitement.

*Discussion of Graph 2:* The injection of sodium amytal here was probably unnecessarily rapid, and the dose was no doubt more than would have been required. The almost immediate change from a state of motor and mental excitement of the animal, with extreme tachypnea and hyperpnea, to a condition of stupor and complete relaxation was very impressive. The respiration became regular, rhythmic and appeared to be approximately normal. No convulsions or spasms appeared after the amytal injection.

*Discussion of Graph 3:* In a relatively short time, twenty minutes, the blood pressure increased from the low level of 65 in Graph 2, to 90, seen at (7) in Graph 3. At this time, although the rate of respiration was about 10-12 per minute, it was of good amplitude. At this point the further injection of 1 per cent novocaine intravenously caused a progressive

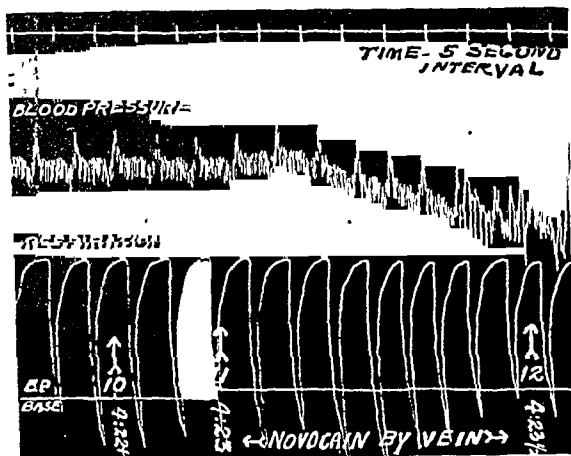
respiration machine was started. It was connected directly with the tracheal cannula, and supplied alternate positive and negative air pressure, with safety valves to insure against excessive pressure changes within the lung. The valves were so arranged that air was taken from the room, introduced into the lungs, and withdrawn and discharged into the room again. The ventilator consisted of a motor driven bellows with adjustable speed and air pressure.

*Discussion of Graph 4:* Here it is seen that within forty-five minutes after a series of 10 violent convulsions due to novocaine, an unnecessarily large dose of sodium amytal intravenously, and a total of almost 1 gm. of novocaine intravenously, the blood pressure is 110, within the normal range, and there is an efficient respiration.

*Conclusions 1.* Despite the criticism of mechanical methods of artificial respiration, by the proper use of adequate artificial ventilation, life can be sustained in most animals which would otherwise succumb to overdoses of novocaine, given by vein or introduced into the spinal canal.

2. Isoamylethyl barbituric acid offers protection against convulsions caused by novocaine. If convulsions are in progress, due to novocaine, this drug or some other safe, soluble barbiturate, is the treatment of choice.

3. Although the isoamylethyl barbituric acid in proper doses will protect against convulsions caused by novocaine,



GRAPH 4. Dog No. 1. 9-27-28.

- 4:22 plus. (10) Blood pressure back to 110. Efficient respiration.  
 4:23 (11) Injection of 1 per cent novocaine by vein, started.  
 4:23½ (12) Definite effect on the respiration, decreased rate and depth, with gradual fall in blood pressure.

it will not prevent the depression brought about by overwhelming doses of the local anesthetic.

4. The combination of isoamylethyl barbituric acid or another safe, soluble barbituric acid hypnotic, with properly controlled artificial respiration, offers the greatest hope for saving of life in cases of severe poisoning by novocaine.

### III. MINUTE VOLUME OF RESPIRATION; BLOOD PRESSURE AND PULSE, EFFECTS OF COMBINATIONS OF SODIUM AMYTAL, MORPHINE, SCOPOLAMINE, ETHER, AND CARBON DIOXIDE

Shonle and Moment,<sup>35</sup> 1923, Dox and Hjort,<sup>36</sup> 1927, and Eddy,<sup>37</sup> 1928, have published results of experiments which indicate that sodium isoamylethyl barbituric acid should be classed among the most effective hypnotics of the barbituric acid series.

Zerfas and McCallum,<sup>13</sup> Lundy<sup>33</sup> and others, have emphasized the value of

sodium amytal as a basal narcotic for general and local anesthesia. For this purpose it is important to know the actions of the drug, particularly upon the functions of respiration and circulation, both alone and in combination with other narcotic drugs, commonly employed in anesthetic work. Detailed studies of the action of the barbiturates on respiration, particularly, have been rather limited. Bouckaert,<sup>38</sup> 1926, reported the effects on the respiration of somnifene, a mixture of diethyl barbituric acid and allyliso-propyl barbituric acid. In doses of 0.2 to 0.4 c.c. for each kilogram of body weight in a rabbit, it caused deep narcosis, greatly reduced the output of carbon dioxide, and diminished the depth and frequency of respiration. Others have emphasized the depressing effect on respiration of large doses of hypnotics derived from barbituric acid both in patients and in experiments on animals.

In this investigation, therefore, special attention has been given to respiration. Data was collected on the blood pressure and pulse rate, largely for the purpose of correlation.

I conducted the experiments with the idea of obtaining evidence as to the effects of preliminary medication on the safety and efficiency factors of anesthesia. The state of the respiration during the narcosis, and its response to stimulation by carbon dioxide was used as the main index to the degree of reduction of vital reserve of the animal. An attempt was made to correlate this information with the degree of hypnosis, analgesia, or anesthesia produced.

*Method.* Clinical methods were employed. The minute volume of respiration was determined by the use of a one-way breathing system, including delicate intake and exhaust valves, an intake bag, and a dry gas meter to measure the flow of air into the breathing bag. An air-tight mask connected the system to the animal. The dose of carbon dioxide was measured and maintained constant at 500 c.c. for each

minute by the use of a Foregger metric gas machine. Rebreathing and obstruction were carefully avoided.

Systolic blood pressure was determined by the auscultatory arm-cuff method, and heart rate by precordial palpation.

As far as possible the same animal was used for successive experiments to avoid the effect of individual variation. Stimulating and depressing effects of operative procedure were entirely eliminated in this series of experiments.

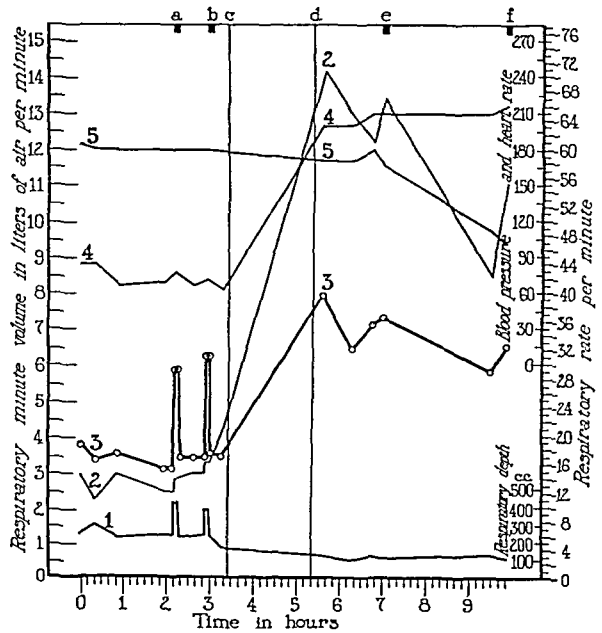
Doses that corresponded to therapeutic amounts in man were administered. Morphine sulphate was given in the proportion of 4 mg. for each kilogram of body weight hypodermically. Sodium isoamylethyl barbituric acid was given in the proportion of 20 mg. for each kilogram of body weight intravenously, in a 10 per cent solution, at the rate of 1 c.c. for each minute. The dosage was kept constant in succeeding experiments of related character.

**Results. Atropine and Ether (Graph 5).** The control minute volume of respiration over a period of two hours is seen to range between 3 and 4 liters per minute (curve 3). At (a) and (b), control measurements of response of the respiratory mechanism to carbon dioxide were made. At (c),  $\frac{1}{100}$  grain of atropine sulphate was given to assist in the control of excessive mucus. The next one and one-half hours were devoted to establishing deep ether anesthesia in the animal.

Deep etherization was accomplished at (d) and was accompanied by the following changes: the rate of respiration (2) increased rapidly to 68. With this high rate of respiration there occurred considerable reduction in the depth (1). As a result of these changes the minute volume (3) was increased to twice the normal value. The breathing became largely diaphragmatic in character. Carbon dioxide in control dosage (e) increased the rate of breathing slightly but decreased the depth during the deep etherization. It had little effect on the minute volume.

Later at (f), when the ether concentra-

tion was lessened to that of a moderate depth of anesthesia, characterized by combined thoracic and diaphragmatic



GRAPH 5. Dog No. 2. 13.4 kg. 11-18-29.

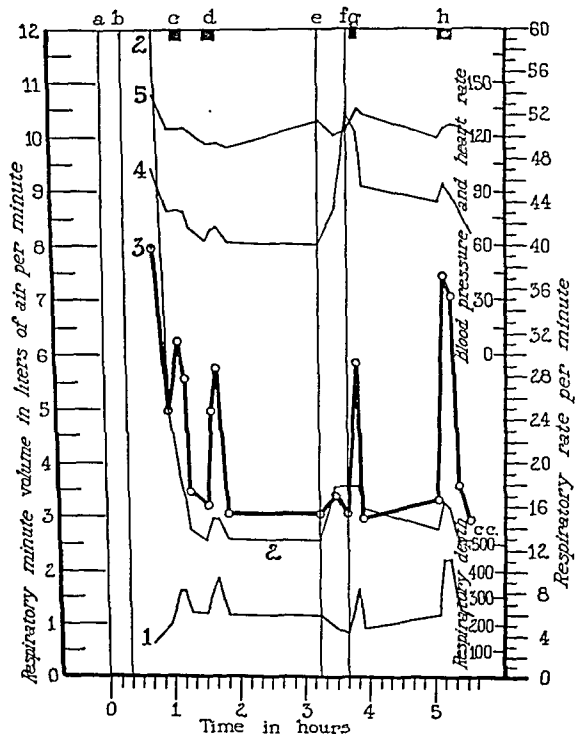
1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg. a, b, c, and f, each 500 c.c. CO<sub>2</sub> per minute in air (five-minute periods).
- c. Atropine sulphate  $\frac{1}{100}$  grain hypodermically.
- d. State of deep ether anesthesia.
- f. Moderate degree of ether anesthesia.

breathing, the control dose of carbon dioxide resulted in a slight increase in the rate of respiration, and in the minute volume.

Two hours of deep etherization were accompanied by a definite fall in systolic blood pressure (5) and a marked acceleration in pulse (4).

**Comment.** It is evident that the rapid shallow breathing of deep etherization resulted in an increase in the minute volume. However, rapid shallow breathing is considered to be a relatively inefficient type of respiration. Furthermore, the absence of thoracic excursions might result in inadequate pulmonary ventilation and in imperfect return of blood to the heart

leading to anoxemia. At this stage it is possible for the central depression of the respiratory mechanism, as a result of



GRAPH 6. Dog No. 3. 17.2 kg. 9-30-29.

1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg.
- a. Sodium amytal 450 mg., 10 per cent solution by vein, 1 c.c. per minute.
- b. Morphine sulphate 1 gr. hypodermically.
- c., d., g., h.  $\text{CO}_2$ , 500 c.c. per minute in air.
- e. to f. Twenty-five minutes of moderate etherization to production of complete anesthesia.

prolonged deep etherization, to render the use of other than small doses of carbon dioxide inadvisable. It has been my experience to observe sudden respiratory paralysis and death in a deeply etherized dog from the use of amounts of carbon dioxide that had formerly been only a stimulating dose.

Lemon's experiments<sup>39</sup> point to the fact that the respiratory reserve of animals deprived of intercostal breathing, and of the activity of a portion of their diaphragms, is lessened when they are sub-

jected to etherization. His animals, prepared by nerve section, could meet the respiratory demands of rather active exertion while awake. They required artificial respiration to sustain life when they were anesthetized with ether.

One might inquire, therefore, as to the true margin of safety remaining after full relaxation has been obtained with ether alone. It would seem that long periods of deep etherization might often dangerously restrict the vital reserve of the animal or patient.

*Morphine, Sodium Isoamylethyl Barbituric Acid, and Ether* (Graph 6). The animal was given a moderate dose of sodium amytal at (a), followed by a small dose of morphine at (b). Profound hypnosis with analgesia developed rather slowly and was not accompanied by full anesthesia with relaxation. Pulmonary ventilation, as indicated by the minute volume, (3), corresponded to that of an animal when at rest, and a high degree of irritability of the respiratory center to carbon dioxide remained. Attention is called to the horizontal level of the minute volume curve between (d) and (e). At (e), full etherization was added and was continued for twenty-five minutes. It was characterized by complete anesthesia and muscular relaxation accompanied by delayed thoracic breathing. Another test with carbon dioxide at this time (g) showed a response equal to that obtained before etherization. Slight acceleration of the rate of respiration with a corresponding reduction in the depth and an increase in the pulse rate accompanied the administration of the ether (e) to (f).

Recovery from the combined effects of morphine, sodium amytal and ether, was rapid and complete. This is indicated by marked improvement in minute volume of respiration seen at (h) as a result of the standard dose of carbon dioxide.

At no time during the experiment was overstimulation or depression apparent in the animal, and the uniform course of events was in sharp contrast to the uneven

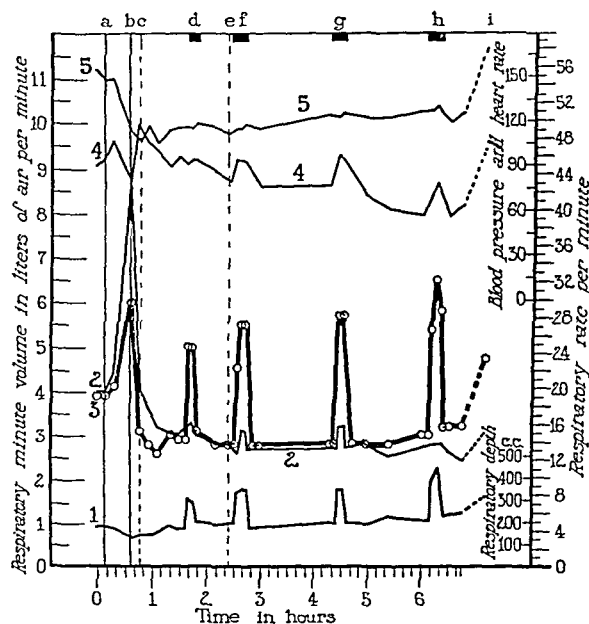
and irregular responses of animal No. 2, under the effects of ether alone.

*Comment.* With a suitable combination and sequence of morphine, sodium amytal and a general anesthetic, such as ether, full surgical anesthesia with relaxation was safely and easily established and adjusted. At the same time there appeared to be retained what may be judged to be a definitely higher degree of respiratory reserve than when ether alone, or ether preceded by morphine alone, was used to a state of similar degree of anesthesia and relaxation.

Other advantages of the preliminary medication are as follows: small doses of morphine followed by moderate doses of sodium amytal produced unconsciousness and analgesia in the animals in a manner in every way analogous to the onset of normal sleep. With the combination, this marked physiological effect can be induced in patients much more safely and effectively than can be accomplished with morphine alone, or even with morphine and scopolamine. At the same time, the small preliminary dose of morphine nearly always greatly reduces the amount of barbituric acid required, and renders its action more uniform, more prolonged and more intense. Both the morphine and the sodium amytal usually considerably reduce, in patients, the amount of general anesthetic necessary as well as the concentration required for complete anesthesia and relaxation. Again, the supplementary effect of the relatively small amount and low concentration of the inhalation anesthetic, or in some instances local anesthetic, minimize the morphine and sodium amytal requirements.

The effects of the inhalation or local anesthetic pass off quickly. The effects of morphine and sodium amytal continue and, with only small additional doses of morphine, at rather long intervals, suffice to control postoperative distress and restlessness. By the use of the morphine, sodium amytal and inhalation or local anesthetic, all in minimal amounts, respira-

tory quiet and impairment of respiratory reflexes, during and after operation, are reduced to the minimum.



GRAPH 7. Dog No. 4. 13.2 kg. 10-1-29.

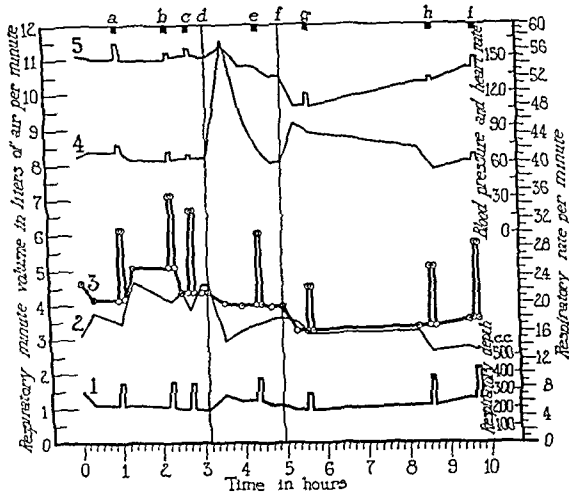
1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg.
- a. Morphine sulphate  $\frac{3}{4}$  grain hypodermically.
- b. Sodium amytal 260 mg., 10 per cent solution by vein 1 c.c. per minute.
- c. to e. Complete anesthesia.
- d., f., g., h.  $\text{CO}_2$ , 500 c.c. per minute in air.
- i. Determination twelve hours later.

Finally, it is to be remembered that, owing to the presence of the barbiturate in the combination, there is complete amnesia for the anesthetic and surgical procedures, and to a large extent in many cases, for the postoperative discomforts.

Bumm's results which were published in 1927,<sup>40</sup> are of interest from the point of view of the use of the barbituric acid derivatives for basal narcosis in general anesthesia. He worked with pernocton which is sodium butylbetabrompropenyl barbituric acid, and recommended that it be used only as an hypnotic to be followed by the production of anesthesia with ether or chloroform. He considered this practice to be in no way dangerous,

and regarded it as a useful procedure in anesthetic work.

Considering the compounds of barbi-



GRAPH 8. Dog No. 4. 14 kg. 11-13-29.

1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg.
- a., b., c., e., g., h., i. CO<sub>2</sub>, 500 c.c. per minute in air.
- d. Morphine sulphate  $\frac{3}{4}$  grain and scopolamine hydrobromide  $\frac{1}{100}$  grain hypodermically.
- f. Sodium amytal 260 mg., 10 per cent solution by vein, 1 c.c. per minute.

turic acid, therefore, as only an aid in the preparation of patients for full anesthesia by inhalation or local anesthetic agents, it was attempted in the later experiments to measure the effects of sodium amytal on the respiration when used alone, or in combination with morphine, or with morphine and scopolamine.

*Morphine and Sodium Isoamylethyl Barbituric Acid (Graph 7).* The morphine was given at (a), and was followed by marked increase in minute volume of respiration (3), due largely to an increase in the rate (2). There was a corresponding decrease in the depth of respiration as seen in curve (1). This result is quite the rule with dogs after morphine administration.

The sodium amytal was given at (b) and was followed very promptly at (c) by return of the minute volume to somewhat below normal, largely as a result of a

decrease in rate of breathing. However, the combination did not result in a reduction of the minute volume of respiration which could be accurately described as a state of depression. It appeared to be rather a state of respiratory quiet, the decline in rate of breathing being compensated by an increase in depth. A good state of irritability of the respiratory center to the stimulating effect of carbon dioxide remained (d). It is noteworthy that these changes occurred in the presence of full anesthesia and marked relaxation lasting about one and one-half hours (c) to (e).

The maximal fall in minute volume was established within twenty to thirty minutes after the drugs had been administered. From this point on, there was gradual, but definite recovery approaching the normal level of minute volume and of irritability to carbon dioxide, (f) to (h).

There was a progressive moderate decline in the pulse rate (4), with an initial fall in blood pressure and gradual recovery toward the control level.

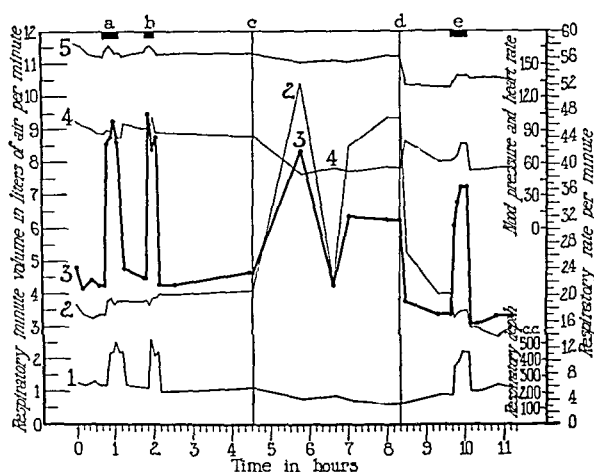
*Comment.* The degree of reduction of minute volume as a result of administration of the morphine and sodium amytal sequence, was seen a number of times when the animal was lying quietly at rest, before any medication had been given. The type of respiration observed corresponded well with that described in dogs in normal sleep.

The rapidity with which the new level of pulmonary ventilation is established, after morphine followed by sodium amytal, facilitates estimation of the maximal reduction in minute volume of respiration which is likely to occur after the administration of these drugs in combination and sequence.

*Morphine, Scopolamine, and Sodium Isoamylethyl Barbituric Acid (Graph 8).* Control determinations of carbon dioxide irritability were made at (a), (b), and (c). At (d) the morphine and scopolamine were administered. The result of this combination was only a slight reduction in minute

volume and carbon dioxide irritability. There was a definite gradual decline in the blood pressure and a marked abrupt

safely reduce the amount of barbituric acid necessary to produce unconsciousness and analgesia. However, the limits of



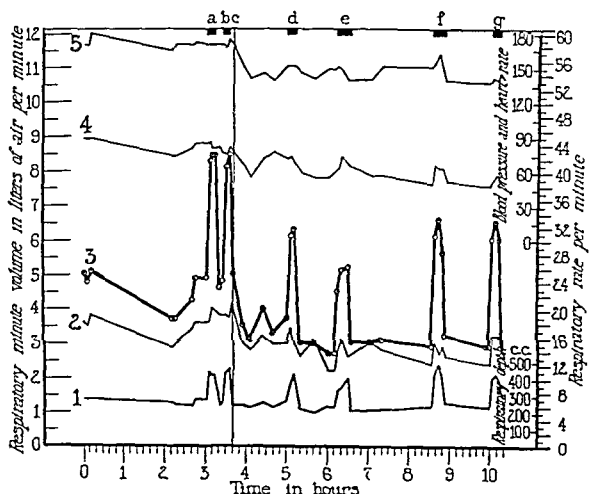
GRAPH 9. Dog No. 4. 13.7 kg. 10-18-29.

1. Respiratory depth in c.c.
  2. Respiratory rate per minute.
  3. Respiratory minute volume in liters of air per minute.
  4. Heart rate.
  5. Systolic blood pressure in mm. Hg.
- a., b., e. CO<sub>2</sub>, 500 c.c. per minute in air.  
 c. Morphine sulphate  $\frac{3}{4}$  grain hypodermically.  
 d. Sodium amytal, 260 mg., 10 per cent solution. By vein, 1 c.c. per minute.

increase in the pulse rate. The latter, however, soon returned to the normal range.

The sodium amytal was given at (f), after which the decline in minute volume was comparable to that following administration of morphine and sodium amytal in other experiments without the scopolamine. There was, however, a somewhat greater decrease in the depth of breathing compared to the reduction in rate. Furthermore, the response of the respiratory mechanism to the administration of carbon dioxide, was reduced more than after the morphine sodium amytal combination of other experiments. However, adequate carbon dioxide responsiveness and minute volume were retained to avoid a state of true depression. The recovery was somewhat more gradual than in the experiments in which scopolamine was not used.

*Comment.* The use of the scopolamine would add a desirable effect, like that of atropine, on secretions, and might further



GRAPH 10. Dog No. 4. 14.1 kg. 10-16-29.

1. Respiratory depth in c.c.
  2. Respiratory rate per minute.
  3. Respiratory minute volume in liters of air per minute.
  4. Heart rate.
  5. Systolic blood pressure in mm. Hg.
- a., b., d., e., f., g. CO<sub>2</sub> 500 c.c. per minute in air.  
 c. Morphine sulphate  $\frac{3}{4}$  grain hypodermically.

safe dosage of scopolamine are considered to be rather narrow, especially when combined with morphine, and when followed subsequently by a general anesthetic such as ether. It does not appear to be necessary to introduce its rather variable effects among those of the morphine sodium amytal combination and sequence, especially if atropine is given to control excessive secretion.

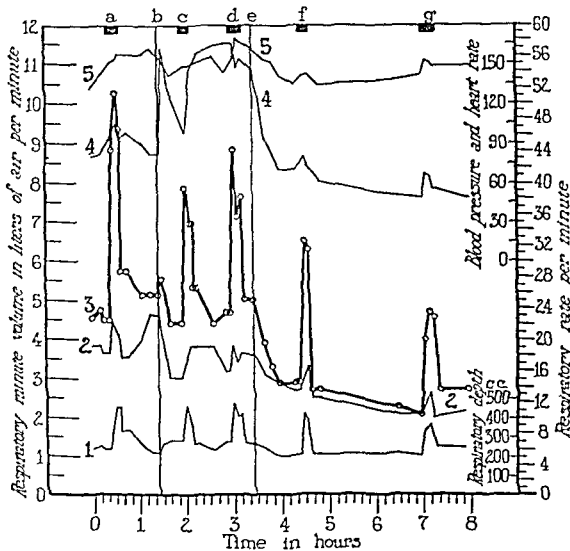
A moderate decline in the minute volume of respiration, and in the irritability of the respiratory center to carbon dioxide, has been described. Patients sometimes appear to undergo periods of slow, shallow breathing soon after or during the administration, especially the rapid administration, of sodium amytal preceded by morphine. An analysis of the foregoing experiments indicates that the changes in respiration are largely the result of a decline in rate. Often a compensatory increase in depth occurred with only slight reduction of minute volume.



Morphine Given Four Hours before Sodium Isoamylethyl Barbituric Acid (Graph 9). The morphine was given at (c),

dioxide, which followed the additional administration of sodium amytal.

Morphine (Graph 10). The morphine

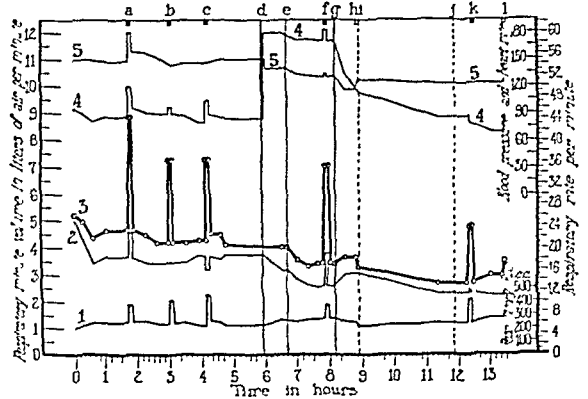


GRAPH 11. Dog No. 4. 13.7 kg. 10-14-29.

1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg.
- a., c., d., f., g. CO<sub>2</sub>, 500 c.c. per minute in air.
- b. Sodium amytal 260 mg., 10 per cent sol. by vein 1 c.c. per minute.
- e. Morphine sulphate  $\frac{3}{4}$  grain hypodermically.

sodium amytal at (d). The usual reduction in the minute volume of respiration after morphine and sodium amytal occurred, perhaps to a slightly lesser degree, but the reduction in the sensitivity of the respiratory center to carbon dioxide was distinctly less than in experiments in which the morphine was followed closely by the sodium amytal.

*Comment.* The results of this and of the succeeding three experiments point to the morphine as being chiefly responsible for the changes in respiration observed after morphine and sodium amytal are given in sequence in therapeutic doses. For example, in this experiment the time allowed for the morphine to be destroyed or eliminated, was apparently important in lessening the degree of reduction of the respiratory center sensitivity, to carbon



GRAPH 12. Dog No. 4. 13.7 kg. 10-29-29.

1. Respiratory depth in c.c.
2. Respiratory rate per minute.
3. Respiratory minute volume in liters of air per minute.
4. Heart rate.
5. Systolic blood pressure in mm. Hg.
- a., b., c., f., k. CO<sub>2</sub>, 500 c.c. per minute in air.
- d. Sodium amytal 260 mg., 10 per cent sol. by vein 1 c.c. per minute.
- e. Sodium amytal 260 mg., 10 per cent sol. by vein, 1 c.c. per minute.
- g. Morphine sulphate  $\frac{3}{8}$  grain hypodermically.
- h. Stimulation. To test anesthesia.
- i. to j. Complete anesthesia.
- l. Stimulation. To test anesthesia.

administered at (c) resulted in a definite reduction in the minute volume of respiration, and in sensitivity of the respiratory center, in both respects equal to that seen when morphine and sodium amytal were combined. The change again was largely due to the decline in rate. The maximal effect developed about two and one-half hours after the morphine had been administered. Gradual recovery of minute volume and irritability to carbon dioxide took place.

*Comment.* In this experiment morphine alone was followed by almost the same total changes in respiratory rate and minute volume as resulted when the morphine was supplemented by sodium amytal. The difference noted, when compared to preceding experiments, is that the decline in rate and minute volume of breathing due to the morphine, apparently, comes on

more rapidly when the morphine is followed by the sodium amytal.

*Moderate Dose of Sodium Isoamylethyl Barbituric Acid and Morphine (Graph 11).* Sodium amytal was given at (b). It was followed by a slight reduction in the irritability of the respiratory center to carbon dioxide and a rather marked increase in the pulse rate. Ample time was allowed for the full effect of the sodium amytal to become established. The morphine was given at (e). Very soon after the morphine had been given, the characteristic fall in minute volume and reactivity to carbon dioxide appeared. The change in the minute volume following the morphine, again was largely due to a decline in the rate of respiration. A notable decline in the pulse rate was observed, following administration of morphine.

*Comment.* In this experiment, no important change in the respiratory minute volume, other than that which could be expected at the onset of normal sleep could be attributed to the sodium amytal. Subsequently, when the morphine was administered, its characteristic effect in reducing the exchange and sensitivity of respiration appeared, apparently unintensified by the previous use of the barbituric acid compound. Therefore, special care should be exercised in the dose of morphine used, and its relation to the time and amount of the barbituric acid compound administered. In addition, particular attention should be given to the rate of respiration following the administration of these drugs in combination.

*Large Dose of Sodium Isoamylethyl Barbituric Acid and Small Dose of Morphine (Graph 12).* A moderate dose of sodium amytal (d) resulted in a slight decline in the rate of respiration accompanied by a compensatory increase in depth. There was no change in the minute volume. The pulse rate showed a distinct and rapid increase. Repetition of this dose of the barbituric acid derivative at (e) produced a slight but definite fall in the minute volume of respiration, due to a

decline in rate, as the animal passed into a deep sleep. The sensitivity to carbon dioxide after the second dose of sodium amytal, remained practically unchanged from the normal. A small dose of morphine given at this time (g) resulted in a further decline of minute volume by additional reduction in the rate of breathing. There was also a definite reduction in carbon dioxide irritability after the morphine as indicated at (k). The characteristic morphine reduction in the pulse rate also appeared. It is to be emphasized that the combined effect of the small dose of morphine and the liberal amount of sodium amytal resulted in full anesthesia and relaxation which lasted for three hours, (i) to (j).

*Comment.* The reduction in the dose of morphine here, as compared to the dose used in the preceding experiment and the increase in dose of sodium amytal, are additional evidence to the effect that the morphine is largely responsible for the respiratory changes due to the combination.

#### SUMMARY

Throughout the foregoing experiments emphasis has been placed on three aspects of the function of respiration as affected by narcotizing agents.

1. The degree of impairment of the normal cooperation and coordination between the intercostal muscles and the diaphragm in the ventilatory process.

2. Variations in the minute volume as determined by accurate measurement of the rate and depth of breathing.

3. The degree to which the respiratory center is affected in its ability to respond to the stimulating effect of therapeutic doses of carbon dioxide.

With methods such as herein described and with suitable tests for determining the degree of anesthesia and analgesia, it is possible that the most advantageous proportions of morphine or other opiate, barbituric acid compounds, and local or general anesthetics, for the production of

basal narcosis and anesthesia, could be established.

Further study is to be made of the effect of larger doses of the narcotics reported; of combinations of other narcotics; and of the influence of various degrees of stimulation and depression as a result of surgical procedures.

The following summary and impressions seem justified at this time.

1. Sodium amytal was found to be very active in preventing and stopping the convulsions, and thereby the spastic paralysis of the respiratory muscles which accompanies experimental novocaine poisoning. With the convulsions eliminated, however, it did not protect against central respiratory paralysis following overwhelming doses of the novocaine. By the addition of well controlled artificial respiration, life of the animals with an efficient circulation was sustained for long periods in the instances in which central respiratory paralysis followed the large doses of novocaine, and in which animals the convulsions were prevented by the use of sodium amytal. Furthermore, preliminary medication of sodium amytal alone, or better in combination with small doses of morphine was observed to reduce the frequency and severity of untoward reactions of patients to local and regional novocaine anesthesia.

2. In the experimental work on sodium amytal as a basal narcotic for general inhalation anesthesia, quantitative determinations were made of the minute volume of respiration and of the ability of the respiratory mechanism to respond to therapeutic doses of carbon dioxide. Such determinations were considered to be of value in estimating the vital reserve, of the animals which were subjected to the effects of the various narcotizing agents.

3. Sodium amytal and other soluble barbiturates should be considered largely if not entirely as only an aid in the preparation of patients for true anesthesia which is to be induced and graduated by the use of local or inhalation anesthetics. For this purpose, complete loss of conscious-

ness, accompanied in many cases by a variable degree of analgesia and relaxation, apparently can be safely and promptly induced by the use of a moderate amount of sodium amytal, particularly if it is preceded by a small dose of morphine or other opiate. The preliminary morphine seems to render the sodium amytal action more uniform as well as more intense, and thereby minimizes the amount of sodium amytal required. By maintaining the minimal doses of both morphine and sodium amytal postoperative unconsciousness and restlessness may be reduced. The preliminary morphine and sodium amytal together materially reduce the amount of local or inhalation anesthetic required for full surgical anesthesia, and also render induction and maintenance of the effects of the inhalation anesthetics more rapid, quiet and uniform. Postanesthetic nausea and vomiting are extremely uncommon.

4. The use of sodium amytal or other soluble barbiturate in suitable combination and sequence with morphine, or alone for the production of basal narcosis may be accompanied by a higher degree of vital reserve than prevails when local or general anesthesia is induced without preliminary medication. This is indicated by the fact that experimentally, in the presence of such basal narcosis, full surgical ether anesthesia was accompanied by a comparatively slight reduction in the minute volume of respiration, a slow but deep and efficient type of breathing, and only a slight reduction in the carbon dioxide irritability of the respiratory center. The fact that minimal amounts of a number of similarly acting drugs were used in combination, with probably slightly different sites of most intense action, rather than relatively large and depressant amounts of any one narcotizing agent, may be of importance in this connection. The elimination of apprehension and induction excitement in patients might also play a part in lessening an often unrecognized or unexpected tendency to shock reaction. On the other hand, it should be remembered

that the combined effects of similarly acting drugs may assume alarming proportions, especially if the dose of each drug is not carefully curtailed and regulated to its desired effect.

5. Basal narcosis as a result of the proper administration of sodium amytal in combination and sequence with morphine, and unaccompanied by morphine in many instances, is followed by amnesia on the part of the patient for the anesthetic and surgical procedures, and for a large part of the preoperative and postoperative discomfort. This action alone is worthy of intensive study and application.

Finally, it may be said that in view of both experimental and clinical evidence, intravenous anesthesia in its broad sense, unsupplemented, uniform, safe and satisfactory to the best interests of the patient, surgeon and anesthetist, is not yet an established fact. Nevertheless, by the use of a judicious combination and sequence of hypnotics, narcotics, local and inhalation anesthetics, it is possible to accomplish every desirable purpose that could be fulfilled by any intravenous anesthetic.

I desire to express my appreciation to Dr. Rowntree, Dr. Lundy, and the Mayo Clinic for their invaluable assistance in the conduct of this investigation, and for the privilege of doing the work in their laboratories.

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# CLINICAL EXPERIENCES WITH THE INTRAVENOUS INJECTION OF SODIUM ISOAMYLETHYL BARBITURATE

AS AN AUXILIARY ANESTHETIC\*

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AMERICAN medicine is credited with having contributed one of the most important advances in surgery introduced in the last century. Since that memorable day of October 26, 1846, when a group of surgeons at the Massachusetts General Hospital stood anxiously by while a dentist deliberately administered inhalations of ether to prepare a patient for a major surgical procedure,<sup>1</sup> many developments in anesthesia have occurred. Some twenty years later, this epochal contribution to surgery by a dentist was reciprocated in part by that master surgeon, William Stewart Halsted,<sup>2</sup> who was the first to make possible the extraction of teeth, and later other operations, by the injection of cocaine as a local anesthetic. In 1885, Corning's<sup>3</sup> discovery of spinal anesthesia opened up another avenue of development, and recent advances in this field<sup>4</sup> are proving to be of inestimable advantage in operative surgery.

Despite these improvements, surgeons, chemists and pharmacologists are still seeking the ideal anesthetic. What, we may well ask, is the ideal anesthetic? In relieving the patient of pain and mental anguish during the operation, the ideal anesthetic will not bring added terrors of its own. The patient will not remember the anesthetizing process as a hideous nightmare, and the worst part of his operative experience. The postoperative nausea of ether still remains one of the most revolting memories that the patient retains, the mere thought of which literally turns his stomach inside out.

Secondly, the ideal anesthetic will induce anesthesia as gently, as quietly and as naturally as sleep itself. No longer will

the patient be plunged into a seemingly endless eternity after a short period of consciousness, and therefore terrifying, struggle against suffocation. Anyone who has been put to sleep consciously will recall the experience only with repugnance.

Thirdly, it will be an anesthetic without irritation to organs of the body in its administration and elimination. It will not add to the hazards of the operation by inimical effects of its own such as ether produces in the air passages, chloroform upon the liver, and cocaine upon the nervous system. After the administration of the ideal anesthetic it will be impossible for a surgeon to shrug his shoulders, side-step all responsibility and mutter accusingly, "ether pneumonia."

Bearing these requirements in mind let us consider what have been our experiences with the most recent addition to our anesthetic armamentarium, namely sodium isoamylethyl barbiturate.<sup>5,6</sup>

Our clinical experience so far covers a group of 150 general surgical cases in which sodium amytal has been employed as an auxiliary anesthetic. There are such very real objections to its use in sufficient quantity to produce of itself complete surgical anesthesia, that we have avoided using it as the sole anesthetic. Briefly, these objections center about its depressing effects upon the circulatory and respiratory centers, and more particularly upon the prolonged continuance of the anesthetic state beyond the operation. When it is administered in full anesthetic doses, the patient may continue in the unconscious state for twelve to eighteen hours. Constant nursing supervision is required to prevent asphyxiation from a relaxed jaw

\* From the Department of Surgery, Stanford University Medical School.  
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and tongue. The intake of fluids is prevented, voiding is omitted, and it is difficult to keep the respiratory passages clear of the accumulating mucus. Moreover, in larger doses, the shallow breathing and drop in blood pressure strikes such terror to the surgeon as well as to the anesthetist that we cannot recommend its use as the sole anesthetic. Our experiences, therefore, deal only with cases in which the sodium amytal has been supplemented by a local anesthetic or by nitrous oxide and oxygen, and to a very minor degree by ether.

When employed in conjunction with infiltration of the operative area with novocaine, certain serious objections have arisen. Clinically it is well known that the barbiturates are particularly useful in counteracting the toxic and convulsive effects of cocaine. Disastrous and fatal poisoning from cocaine may be forestalled by the preliminary administration of barbitol either by mouth or subcutaneously, as advocated by Martin.<sup>7</sup>

A similar antagonism is noted when a barbiturate is employed in conjunction with novocaine. The patient, who has fallen into a deep sleep with the administration of the amytal, suddenly appears to waken after the first few cubic centimeters of novocaine have been injected. Painful stimuli cause uncontrollable struggling and the only way out has been the addition of nitrous oxide anesthesia.

The successful use of a local anesthetic is dependent to a certain degree upon the cooperation of the conscious patient. The ungoverned and irresponsible actions of a patient who is only half asleep and half conscious are obviously to be avoided. It is preferable, therefore, when contemplating its use with novocaine to give only sufficient amytal, 4 to 6 grains, to produce drowsiness, from which the patient may be easily aroused to assist and cooperate with the surgeon. When applied in this way it has been found of very definite advantage in operations upon the nasopharynx in individuals who are of a very nervous, excitable temperament, whose

gag reflex is extremely sensitive and to whom the surgeon does not wish to give a general anesthetic. The operation is less of a fight and more of an artistic accomplishment when such patients are made drowsy by the use of sodium amytal, or if you like, by scopolamine and morphia. It would appear that the range of operation to be performed on the nasopharynx under local anesthesia can be materially extended to a larger group of patients by the addition of small doses of sodium amytal.

In our experience thus far its greatest usefulness has been in extending and facilitating the use of nitrous oxide anesthesia. The usual preliminary preparation with morphine and atropine is employed. On arrival in the operating room, the sodium amytal is introduced intravenously at the rate of  $1\frac{1}{2}$  grains per minute, or even more slowly. The amount so administered varies remarkably with different patients, there being a very definite individual susceptibility to the effect of the drug. This is apparently true of all the barbiturates. Accordingly, the drug is slowly administered until the patient is fully asleep, the amount varying usually from 7 to 12 grains. An additional 3 to 5 grains are then administered beyond the amount necessary to induce sleep. In one man weighing 180 lb. with a severe secondary anemia and 40 per cent hemoglobin, sleep was induced after only 5 grains had been administered, whereas another patient, a spare woman of 115 lb., received 20 grains before she showed any evidence of going to sleep. Obviously to administer the drug according to body weight would be quite absurd. The usual dose for the adult as employed at present at the Stanford Clinic is from 7 to 12 grains although Lundy at the Mayo Clinic has given as high as 45 grains with impunity.

A second guide as to the amount of the drug to be administered is its effect upon the general blood pressure. The usual fall is from 20 to 40 points, the maximum fall occurring at the moment the patient goes to sleep. When the fall in blood pressure is

abrupt and great, its administration is immediately discontinued. It is our belief that a personal idiosyncrasy to the drug is manifested by a profound effect upon the blood pressure, and any fatality from this cause should be avoided by carefully checking the blood pressure during the administration of the drug. Sleep is induced without the slightest struggling, the patient dropping off as naturally as in normal sleep. The patient is wheeled into the operating room, where the field is prepared and draped. At any moment, if the patient becomes aroused, the nitrous oxide is begun, usually in full concentration at first, but after the incision through the skin has been completed a leaner mixture is required with often as high as 30 per cent oxygen. It is believed that the actual total amount of nitrous oxide necessary for continued anesthesia is correspondingly decreased. Abdominal operations may occasionally be performed without the addition of ether, although in several instances a small amount of ether was found necessary to secure the necessary relaxation of the abdominal wall for the approximation of the peritoneum and posterior sheath of the rectus.

Upon the withdrawal of the nitrous oxide at the completion of the operation the patient may usually be easily aroused, but he drops promptly to sleep when transferred to a warm bed. After these smaller doses of the drug, the patient can always be aroused to void, to take fluids and to clear his throat. There is, however, an amnesic period of from twelve to eighteen hours of which the patient remembers little, and he often wakes up from his experience, wondering when the operation is to be performed. During this period, a nurse is in constant attendance and the patient is kept on one side to prevent swallowing of the tongue and asphyxia.

If at the end of the operation the blood pressure is low, ephedrine sulphate is administered in doses of  $\frac{3}{8}$  and  $\frac{3}{4}$  grain. A restless, half-unconscious patient may

often be fully aroused by giving ephedrine and rather large doses of 8 to 10 grains of caffeine sodium benzoate. This combination of ephedrine and caffeine is considered the best and really only antidote available. If there is marked restlessness after the operation with delirium, morphia may be administered to excellent advantage.

In the highly nervous patient, as in exophthalmic goiter, the drug is administered in the patient's room and the patient avoids the terrifying experience of approaching the operating room.

As a rule, the patients exhibit very little nausea and vomiting after the operation, even after the intra-abdominal procedures. The nurses have claimed that the amount of care following the use of amytal is definitely decreased during the first twelve to eighteen hours following operation.

In addition to its use as an adjunct to general anesthesia, sodium amytal is of distinct value in other clinical fields. Drabkin<sup>8</sup> and Robbins<sup>9</sup> et al have recently reported their experiences in the field of obstetrics.

Numerous other clinical applications of the barbitol compounds including amytal have been recorded by Weiss<sup>10</sup> and Lundy.<sup>6</sup> In certain types of psychoses sleep has been maintained for as long as forty days on a dosage of 5 to 10 grains daily. Post-operative psychoses have been successfully controlled. Status epilepticus has been controlled by 6 to 15 grains of sodium luminal administered intravenously.

The toxic manifestations of cocaine such as convulsions may be immediately dispelled by the intravenous injection of 7 to 15 grains of sodium luminal or amytal. In tetanus, the generalized spasm of the musculature with recurrent convulsions may be controlled and the patient spared a terrifying experience by the intravenous injection of 10 to 20 grains of sodium amytal.

Persistent hiccups have been controlled by amytal. Intense pain unrelieved by morphia has on occasion yielded to the intravenous injection of 10 to 15 grains of



amytal as in a case of a broken back, a case of extensive burns which ended fatally, and a case of gastric crisis. A patient with severe generalized pruritus from jaundice was kept comfortable by the administration of 4 grains by mouth at four-hour intervals. Postoperative convulsions following a craniotomy yielded to small doses by vein, as also convulsions following cranial injuries. MacCallum<sup>11</sup> found it of value in the treatment of delirium tremens, and Mehrtens<sup>12</sup> in the treatment of drug addiction.

Summarizing these clinical experiences with amytal we may say that it provides a convenient way of administering the purified drug in many situations in which prompt sleep or prompt relief from pain or convulsions is desired.

As an anesthetic, however, it is subject to definite limitations. Once injected into a vein, it cannot be retrieved, and to date it is difficult to counteract the drug once it has been administered. Ephedrine (grain  $\frac{3}{8}$  to grain  $\frac{3}{4}$ ) and caffeine sodium benzoate (grains 7 to grains 10) are the only agents available to counteract the effects of the drug.

The occasional restlessness and mild delirium after operation are a definite disadvantage but are usually absent when amytal is administered in the smaller doses of from 7 to 12 grains. When present restlessness should be controlled by morphia.

The drop in blood pressure is a distinct disadvantage. Even with small doses this drop may be alarming and sufficient to warrant postponement of the operation. It may be an evidence of an individual idiosyncrasy to the drug, and its possible appearance makes imperative frequent observations on blood pressure during the administration of the amytal. It is our opinion that once a fall in blood pressure has occurred, the stability of the vasomotor center has been slightly impaired and a second drop is more likely to occur. The disadvantage of this is obvious when shock and an accompanying fall in blood

pressure are likely to result from the operative procedure itself.

The use of sodium amytal is avoided or limited to small doses in operations upon the jaw, tongue or mouth, since any postoperative drowsiness would prevent the proper expectoration of saliva or mucus which invariably accumulates in the throat following such procedures.

Its advantages in the operating room may be briefly summarized as follows:

1. Amytal provides the normal induction of a natural sleep without the apprehensive struggling of a conscious patient. A patient may be put to sleep in his own room and return to the room without any knowledge of ever having left it.

2. All preparation of the patient with respect to position on the table, cleansing and draping of the operative area may be performed before the administration of the inhalation anesthetic.

3. There is a marked reduction in the amount of nitrous oxide that is necessary to produce full anesthesia, and cyanosis is avoided. The amount of oxygen which can be added to the nitrous oxide-oxygen mixture is increased, the percentage varying between 16 to 32 per cent oxygen.

4. With the use of amytal we may avoid the struggling on the part of certain apprehensive patients who cannot be kept fully anesthetized on nitrous oxide alone without marked cyanosis or without the addition of ether.

5. Abdominal operations may be performed without local anesthesia under nitrous oxide inhalation, with the addition of a slight amount of ether while closing the peritoneum.

6. There is a marked reduction in postoperative nausea, in the postoperative struggling of a patient and in postoperative care.

7. Patients remain amnesic for twelve to twenty-four hours and become fully conscious at the end of this period with very little remembrance of the operation or the immediate postoperative period. The need for postoperative morphia is greatly reduced.

8. Patients who had experienced other operations under ether anesthesia claimed that sodium amytal rendered their present operation a pleasant experience in marked contrast to the ordeal through which they had previously passed.

In operations upon patients with exophthalmic goiter, and upon the very appre-

hensive and easily excitable patient, sodium amytal has, we believe, a very definite place in anesthesia, and may be used in doses of 7 to 12 grains with definite advantage to the patient. From our brief experience, however, it is obvious that the ideal anesthetic, as originally described, is not yet available.

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# INDUCTION ANESTHESIA BY SODIUM AMYTAL\*

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THE number and variety of anesthetic agents being employed today are an evidence of the fact that the ideal method has not yet been developed. Surgeons generally are giving greater thought and attention to the proper selection of the anesthetic. In conjunction with the anesthetist, the choice of procedure is made on the basis of the individual requirements of a given case. The proper determination of the type of anesthesia is of equal importance to the performance of the technical procedure of the operation.

Inhalation anesthesia, administered under the most approved methods, has certain distinct disadvantages. Chief of postoperative sequelae are the occurrence of respiratory complications, nausea and vomiting. Patients suffering from diabetes, nephritis, alcoholism, pulmonary infections and shock, are not good subjects for general anesthesia.

The employment of spinal anesthesia has become quite extensive during the past few years and its popularity is increasing steadily. The appreciation of its wide range of applications, its safety and the better knowledge of its technical application and possible dangers, are more general in acceptance. The pioneer work of Labat, Babcock and Pitkin has done much to enlighten the profession in the proper employment of spinal anesthesia.

In the past eighteen months, a series of over 200 patients of all kinds have been operated on, with the employment of spinal anesthesia alone. Our satisfaction with its employment increases with experience. In abdominal work, the relaxation obtained facilitates technical manipulation and speed in accomplishment, lessening the need for employment of pads, thereby preventing some of the postoperative adhesions. The lessened occurrence of

postoperative respiratory complications is striking, only 1 case of pneumonia having developed in our series.

In unskilled hands, it has definite dangers and should be used with care and discrimination. Observance of technical details, skill in the administration, proper teamwork by operator, anesthetist and nurses, are essential.

With some patients various conditions, such as undue apprehension, unstable psychic poise, thyroid toxemias and a variety of contraindications to the patient's knowledge of the personnel and environment of the operating room exist. In such a group, the induction anesthesia by means of the intravenous injection of an aqueous solution of sodium amytal is of great value, in conjunction with a supplementary spinal or gas oxygen anesthesia. The advantage of the intravenous over oral or rectal administration is the speed and ease with which sleep is induced. It also results in more accurate dosage as individual susceptibility varies, the administration being terminated when the desired depth of sleep and relaxation is obtained.

The analgesic effects of the barbituric group of drugs, to which belong veronal, luminal and sodium amytal, are well known, as is the antidotal action of this group for procaine, which may account for the fact that fewer toxic manifestations were noted in the amytal intraspinal than in the intraspinal anesthetics alone.

The experimental work of Zervas and McCallum of Indianapolis, first called attention to its practical possibilities. DeTakas of Chicago and Brown of Santa Barbara, have reported their experience with its use. We have observed its practical demonstration by Sise of the Lahey Clinic of Boston and Buchanan at the New York Post-Graduate Hospital. Our

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own experience comprises a group of 40 cases in which sodium amytal was used, at the Memorial Hospital, Orange, New Jersey.

Sodium amytal alone may be sufficient for the anesthesia required for minor surgical procedures, such as, dilation and curettage, hemorrhoidectomies, intrauterine application of radium and for making differential diagnoses of abdominal and pelvic conditions in patients difficult to examine. In one patient, a woman of twenty, presenting symptoms of an acute lower abdominal lesion, the differentiation between an acute appendicitis and salpingitis was made certain by the aid of the complete relaxation obtained with the use of 0.6 gm. of sodium amytal. The ovary and an enlarged tube were palpated, a gangrenous unruptured appendix lying low in the pelvis, was recognized and prompt surgical attention was followed by a good result. In the small dosage employed in our cases, (the average dose being 0.8 gm. and the maximum being 1.0 gm.) it was found insufficient for major work and was supplemented by spinal or gas oxygen anesthesia.

Many patients fear an anesthetic more than an operation. To some, the journey from the bedroom to the anesthetic room in the operating department, offers an unwelcome experience. The ease and comfort of the production of a quiet profound sleep, by simple intravenous injection, are most acceptable to the patient. The approval of such a means, by harassed and anxious relatives, is positive.

Experience has demonstrated that the employment of a hypnotic the night before, insuring a preliminary rest and affording an opportunity to detect any unusual susceptibility to the barbitol compounds, is advisable, veronal and luminal being employed. A preliminary hypodermic of  $\frac{1}{6}$  grain morphine and  $\frac{1}{150}$  grain atropine makes the patient still further receptive. The effect of sodium amytal on the respira-

tion is to make it slower and more shallow. If undue depression is manifest, the inhalation of  $\text{CO}_2$  and oxygen will quickly restore it to normal. The pulse rate is made slower, the effect on the blood pressure is usually pronounced and the average in our series was a reduction of 46 mm. systolic and 23 mm. diastolic. The greatest fall was a reduction of 150 mm. in systolic and 70 mm. diastolic in a case of tetanus in which it was employed. This case well demonstrated the antispasmodic effect of the drug. Violent tetanic convulsions were completely controlled by the use of 2 gm. One grain of ephedrine given hypodermically restores the pressure to normal promptly. In all cases this was given with the local infiltration of novocaine, prior to administration of the spinal anesthesia.

Following is a brief synopsis of observations noted in 40 cases.

Ward cases.	18
Private cases.	22
Oldest patient	70
Youngest patient	14
Average age	40
Shortest period narcosis	1 $\frac{1}{2}$ hr.
Longest period narcosis	22 hr.
Average period narcosis	7 hr.
Cases with amytal alone	5
Cases with spinal anesthesia	28
Cases with spinocaine .	18
Cases with neocaine .	10
Cases with gas, oxygen	7
Average dose spinocaine	3 $\frac{1}{2}$ c.c.
Average dose neocaine	14 gm.
Nausea and vomiting following	9
Cases requiring catheterization.	4
Cases of mild delirium	4
Hysterectomies.	6
Appendectomies	4
Salpingectomies and appendectomies	2
Salpingectomy and oophorectomy.	1
Exploratory laparotomies	3
Implantation of radium	1
Dilatations and curettages	2
Double salpingectomy	1
Herniotomies	2
Cholecystectomies.	9
Amputation (leg).	1
Hemorrhoidectomy	1
Uterine suspensions.	3
Vaginal examinations	2
Perineorrhaphy	1
Tetanus case.	1

# SODIUM AMYTAL IN GENERAL SURGERY\*

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**S**ODIUM amytal is a valuable drug for many purposes. Its action and uses may be best understood by considering it a splendid intravenous hypnotic instead of an anesthetic.

After an experience of 22 cases we prefer to use it as an adjuvant only to nitrous oxide, ether or novocaine locally. We have not yet used it with spinal anesthesia but believe it would be perfectly safe and very valuable for high-strung and nervous patients who are restless under spinal anesthesia alone.

Our preliminary preparation has consisted of 10 grains of chloretone at nine P.M. of the day preceding operation and 10 grains of chloretone at seven A.M. on the day of operation. A hypodermic of morphine  $\frac{1}{6}$  grain or  $\frac{1}{4}$  grain is given a half-hour preceding operation. There seems to be some respiratory depression from sodium amytal so the patient should not be over morphinized. We have not seen any ill effects from these doses. The dose varies with the weight of the patient.

Theoretically it would be almost ideal to give sodium amytal to the patient in his own bed before he is placed upon the stretcher and carried to the operating room. This would eliminate much of the fear and nervousness of sensitive patients. We have found it to work well and when it is given this way, the patient has no knowledge that the operation has been performed. We thought that it could be given in a general ward behind screens without the other patients realizing that anything unusual was taking place but found that it created much interest in the other occupants of the ward. The reaction was interesting, however, for the patient in the next bed, who was to be operated upon later, remarked "I wish that you would do it to me like that." As a routine

procedure it adds somewhat to the work and there is the disadvantage that the narcotized patient should not be left alone with a nurse, who is not especially trained for the purpose, during the trip from the bed to the operating room.

We have usually administered the sodium amytal in the operating room. The standard dose is 1 gm. dissolved in 10 c.c. of distilled water. After a clear and colorless solution has been obtained it is given intravenously. The anesthetist takes the blood pressure and calls off the half minutes during the injection which should take ten minutes. A comfortable position, with both elbows supported and the tip of the index finger of the left hand resting upon the hub of the needle, allows relaxation. A careful watch is maintained for the moment when unconsciousness first supervenes. This is the index of the patient's susceptibility to the drug. If 4 c.c. of the solution have been given the response is normal, for most individuals are sound asleep at this time. If a little of the mixture enters the subcutaneous tissue it need occasion no alarm for we have had no sloughs from such an accident. When snoring commences the head is turned to the side and extended to prevent the base of the tongue from dropping back.

There is an occasional case that requires nothing in addition to the sodium amytal for an appendectomy or herniorrhaphy but nearly every patient who receives only 1 gm. of the drug will require a little ether, nitrous oxide or ethylene in addition. The anesthetists say that the amount required is about  $\frac{1}{3}$  that usually given alone. One hysterectomy needed only 6 drs. of ether after the sodium amytal. A cholecystectomy had  $5\frac{1}{2}$  oz. of ether by the wasteful open drop method for an operation that took nearly an hour. When

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SERIES OF SODIUM AMYTAL CASES

Hosp. Number	Operation	Dose of Amytal (Grams)	Supplemental Anesthesia	Complications
36081 Norwegian H.	Appendectomy	1	0	Granular casts and albumen. Normal three days later
135449 Methodist H.	Appendectomy	1	Nitrous oxide	Toxic dermatitis
136472	Appendectomy	1	Nitrous oxide	0
136539	Appendectomy	1	Nitrous oxide	0
136548	Appendectomy	1	Nitrous oxide	0
136603	Appendectomy	1 1/2	0	0
136651	Appendectomy	1	0	0
134672	Cholecystostomy	1 1/2	Nitrous oxide	Edema of lungs. Dilated heart. Died
135527	Cholecystectomy	1	Nitrous oxide	0
136594	Cholecystectomy	1	Ether 5 oz.	Infection tube drainage tract.
136721	Cholecystectomy	1	Ether 2 oz. Nitrous oxide	Infected gall bladder. Wound drained. Pus later
136745	Cholecystectomy	1	Ether 1/2 oz.	Severe bronchitis
37379 Norwegian H.	Hysterectomy	1	Ether 7 drs. Nitrous oxide	0
135107	Myomectomy Appendectomy Release intestinal adhesions	1	Nitrous oxide	Infected wound
135391	Pelvic repair Appendectomy Coffey suspension	1	Nitrous oxide	0
135530	Dilatation Curettage Insertion radium	1	0	Flighty. Muscular twitching. Hysterical 24 hours after op. Cured by morphine sulphate
134629	Herniorrhaphy	1	Nitrous oxide	0
134766	Herniorrhaphy, bi-lateral	1 1/2	0	0
136592	Herniorrhaphy, bi-lateral	1 1/2	0	0
135471	Gastroenterostomy	1	Ether 2 1/2 oz. and nitrous oxide	Postop. pneumonia. Recovered
136635	Wiring fractured jaw (contraindicated)	1	0	Cyanosis and poor breathing. Relieved by traction on tongue
136597	Subtotal thyroidec-tomy	1	Nitrous oxide	Infected wound

used with sodium amytal a little gas will give a relaxation that is not seen without it. These small amounts of the additional anesthetic must mean less concentration in the blood, less saturation and poisoning of the tissues and a more rapid and less damaging elimination. Our experience verifies this. Vomiting is very rare during

the first twenty-four hours and in most cases never occurs at all during convalescence. An occasional case shows rather marked restlessness bordering on delirium as the patient awakes from sleep. This is unpleasant, if allowed to continue, but it yields very promptly to a hypodermic injection of morphine and does not recur.

It probably happens in less than 10 per cent of the cases. The time of awakening averages about six hours after the 1 gm. doses. It varies from two to ten hours. Some patients wake up, ask for a drink, turn over and then sleep for five or six hours longer. There is seldom any complaint of pain within the first twelve hours.

The operative wounds heal kindly. The blood chemistry does not show any marked changes. The urine usually is concentrated for a day or two and shows a faint trace of albumin. The tongue may be a little coated and dry, possibly from breathing through the mouth. In forty-eight hours there is a close approach to normal.

*Complications.* These cases were all operated upon during the winter months when the incidence of respiratory infections is always high. The shallow respirations and mouth breathing induced by sodium amytal may possibly favor such complications although the average time before awakening was only six hours.

There has been only one death in our series. This was a man thirty-eight years old, an alcoholic, as we discovered later, who was operated upon with the mistaken provisional diagnosis of acute cholecystitis. He showed a positive direct and indirect Van DenBergh test. His icteric index was plus seventy. He received  $1\frac{1}{2}$  gms. of sodium amytal but it was necessary to use additional nitrous oxide because he moved during the operation. An advanced cirrhosis of the liver was found without cholecystitis. He died twelve hours after operation from edema of the lungs and a dilated heart. He was fully conscious for several hours before death and was never deeply unconscious so that he could not be easily aroused. Doctor Eli Lilly, under date of January 14, 1930, says, "So far

as we know there have been no deaths directly attributable to Amytal . . . Such would seem to be the situation in your case."

The toxic dermatitis, seen in one case, we believe was caused by the sodium amytal. So also was the transient renal irritation found in the first appendicitis case.

This drug should not be given in cases of fractured jaw when the jaws are to be wired and the tongue may drop back.

The thyroidectomy for hyperthyroidism followed the regular rule that these patients will tolerate relatively large doses of the sodium amytal. After 1 gm. had been given the patient still moved her head and she was conscious and moved as soon as the operation had been completed and the nitrous oxide discontinued. Her unusually rapid convalescence causes one to wonder if sodium amytal may be chemically and physiologically antagonistic to thyroxin and by neutralizing it prevent post-operative hyperthyroidism. However, "One swallow doesn't make a summer."

Several clean cases showed some wound infection following operation but sodium amytal did not cause this. There was a mild hospital flurry of infections on several different services at the time. Most of the cases did not receive sodium amytal.

*Conclusions.* Sodium amytal seems to be a safe and valuable ally in general surgery when used in moderate doses. It allays nervousness and apprehension; reduces the amount of ether or nitrous oxide to a negligible quantity; gives an easy, painless recovery without vomiting during the first hours following operation and leaves the memory free from the disagreeable impressions so often left after many operative procedures.



# INTRAVENOUS SODIUM ISOAMYLETHYL BARBITURATE

## WITH SPINAL ANESTHESIA\*

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SPINAL anesthesia has proved itself to be so valuable that it has become an essential part of the activities of every well organized anesthesia department. The reaction of different individuals to the conscious state during an operation under this anesthesia varies considerably. Some do not object to it and are even interested to know what is going on. Most people, however, prefer unconsciousness or at least some dulling of consciousness. The position on the table for an abdominal operation is uncomfortable, especially if the operation is at all prolonged. Various sounds, such as the click of forceps, the gurgling of intestines, the noise of the suction apparatus, and the talk of the surgeon are unpleasant, and to the apprehensive may be extremely disturbing. With most patients, therefore, a certain amount of narcosis is highly desirable.

There are a few patients who are so apprehensive and whose nervous systems are so constituted that the conscious state during an operation under spinal anesthesia, particularly an abdominal operation, even with some narcotic medication, constitutes a mental ordeal to which they should not be subjected. This was particularly borne in upon me in interviewing a lady before her operation under spinal anesthesia. She recounted to me how a friend had told her that she had heard a surgeon ask for a knife during her operation. My patient said that this incident seemed to her so horrible that she could not credit it as being possible. I believe that we who are inured to operating room procedure cannot appreciate what an abdominal operation in the conscious state means to such an individual, but I do feel quite sure that such individuals should not be conscious during their operation.

It is customary before most operations to give a certain amount of quieting medication. In our early work with spinal anesthesia we found that a large number of patients, in spite of this preliminary medication, objected to the mental aspect of being operated upon under spinal anesthesia. We, therefore, gradually increased the amount of preliminary medication and found that this materially helped the mental condition of the patient. This procedure has worked out very well with the majority of patients; but there is a small group with whom it has not been so successful. This group constitutes the apprehensive and hypersensitive individuals to whom I have already referred.

This group was not satisfied unless they were rendered entirely unconscious. But, in the attempt to get a sufficient amount of preliminary narcotic medication in the usual way to produce this effect, certain difficulties were encountered. It was found that the effect of a predetermined dose of narcotic drugs varied so much with different individuals that it was impossible to gauge its effect with sufficient accuracy. In spite of our best efforts, some of the patients remained conscious, while others fell into such deep narcosis that an undesirable degree of depression resulted. Many, whether unconscious or not, had skin sensation so dulled that it was impossible to determine before operation the extent of the spinal anesthesia. This, we felt, it was quite important to determine, because if the spinal anesthesia was not already high enough, we could raise it by shifting the position of the patient. We found that the great majority of our failures to get proper height of anesthesia with spinal occurred in these cases and was due to a deceptive skin test. We thought that we

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had gotten the anesthesia high enough, but found when the operation started that we had not.

These difficulties have been entirely overcome by the use before operation of intravenous sodium isoamylethyl barbiturate. In the first place, the effect of the drug can be gauged quite accurately so that patients are seldom either too light or too deep. The intravenous route causes the drug to enter the circulation very rapidly so that a maximum effect is produced immediately. On the conclusion of the injection this effect lessens quite rapidly for a short time and thereafter so slowly that for purposes of the operation, it remains practically constant. This lesser degree of narcosis is the one which we want to obtain. While allowance must be made for this lessening of narcosis immediately following the injection, yet the degree of lessening appears to be so constant that with a little practice the proper allowance can readily be made. To get the desired degree of narcosis, we adopt roughly the following procedure: Injecting the drug slowly, we wait until the patient is unconscious, with absent lid reflex, and usually with a little stertor, and then inject about 25 per cent more than we have already given, when the skin reflex will usually be found to be abolished. The amount of the drug necessary to accomplish this is usually about 0.6 to 1.0 gm. A few patients will become restless during operation, even though still unconscious. This restlessness can usually be controlled, if taken early, by  $\frac{1}{6}$  to  $\frac{1}{4}$  grain of morphine, sometimes with the addition of nitrous oxid for a few minutes.

The second advantage of this drug is that we can readily test for the height of anesthesia. I can recall but 2 cases in which this was not possible. Due to the rapid lessening of narcosis already mentioned it is found that by the time spinal anesthesia has been given, skin reflexes have returned, so that test for anesthesia can readily be made. Indeed, by this time, in spite of the fact that the patient is entirely uncon-

scious, skin reflexes are quite lively so that no doubt whatever exists as to the height of anesthesia. This we feel is quite important.

This narcosis has, of course, the advantages and disadvantages common to the use of sodium isoamylethyl barbiturate. As the dose of the drug is not large, however, the disadvantages are not prominent and they are much more than counterbalanced by the advantages of unconsciousness and skin sensitivity, together with other advantages such as lack of vomiting both during and after operation, and the presence of considerable post-operative amnesia.

The technic of intravenous injection is that usually employed with this drug and need not be detailed here. A few points, however, do require special mention.

With this drug given intravenously, a certain amount of fall in blood pressure is to be expected. A fall in blood pressure just preceding the administration of spinal anesthesia is undesirable. With the young and vigorous this fall is slight and the pressure soon returns to normal. This condition need cause no concern. With the weak and elderly and especially with the hypertensive and sclerotic this fall, however, may be considerable and the pressure may return grudgingly if at all towards normal. Such patients make poor subjects for this procedure.

Between these two extremes lie the great majority of patients. These patients get a slight to a considerable fall of pressure, yet with a little care will make good subjects for spinal anesthesia. If one but waits a while, the pressure will return toward normal. This, however, is a waste of time and is unnecessary, as the pressure can be kept from falling by the use of ephedrine. Ephedrine is commonly given as a prophylactic before spinal anesthesia and can just as well be given a little earlier, with the sodium isoamylethyl barbiturate. If the contents of the usual ampule of ephedrine, containing 50 mg., are added to the usual amount of sodium isoamylethyl barbiturate, namely: 10 c.c. of a 10 per

cent solution, the drug will be precipitated and a slight murkiness will result. This is undesirable. Approximately half this amount, however, 25 to 30 mg., can usually be added without causing precipitation. If this amount of ephedrine is given intravenously with the narcotic drug, the resulting drop in pressure will usually be absent or negligible. A few susceptible individuals will get a moderate fall in pressure in spite of this. If it is suspected that the individual belongs to this class, it is well to give the other half of the ampule of ephedrine, namely 25 mg., subcutaneously before starting the intravenous injection.

With some experience, care and discrimination, it will be found that patients can be quite consistently brought to the operating table for spinal anesthesia entirely unconscious, retaining active skin reflexes, and with little or no fall in blood pressure.

This procedure is especially applicable to the extremely nervous and apprehensive who are young and in good condition. It is not suitable for the very elderly, hypertensive or sclerotic.

#### CONCLUSIONS

This procedure has the disadvantages common to the use of sodium isoamylethyl barbiturate and to that of spinal anesthesia. Its field is somewhat narrow and limited; but in its field, with hypersensitive individuals, in good condition and having an abdominal operation, it has many advantages. It gives them the greatest possible comfort over the trying period of operation, the best possible operating conditions for abdominal surgery, and withal the comparative absence of toxic or injurious effects on the tissues and functions of the body.



# SUPERFICIAL CERVICAL PLEXUS BLOCK ANESTHESIA FOR THYROIDECTOMY\*

RICHARD B. STOUT, M.D.

MADISON, WISCONSIN

**G**AS-OXYGEN anesthesia for thyroidectomy has the disadvantage of causing vascular engorgement and,

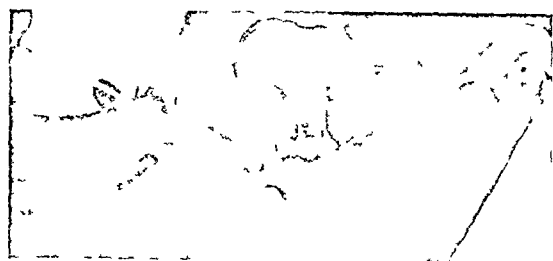


FIG. 1 Initial intradermal wheal of 1 per cent novocaine raised just lateral to sternal origin of sternocleidomastoid muscle.

therefore, a more soiled operative field than local anesthesia. Infiltration anesthesia is superior to gas in many respects, but it has been supplanted at the Jackson Clinic by the superficial cervical plexus block because of the many advantages of the latter method. Many technics have been described for both superficial and

hour before operation. Ten grains of sodium barbital is also given by mouth to reduce the toxicity of novocaine, in case of accidental intravenous injection.<sup>3</sup> Pantopon grain  $\frac{1}{3}$  may be repeated immediately before the anesthesia is induced. The surgical field is prepared and a 27 gauge 1 in. needle is used to raise an initial wheal of 1 per cent novocaine just lateral to the sternal origin of the sternocleidomastoid muscle on each side. The patient's head is then turned to one side and the neck extended, stretching the sternocleidomastoid muscle, and a  $4\frac{1}{2}$  in. 22 gauge needle is inserted through the skin wheal. The needle is then gently passed up just posterior to the belly of the sternocleidomastoid muscle almost as far as the mastoid process. Palpation of the tip of the needle through the overlying skin helps to keep it superficial during insertion. About 15 c.c. of 1 per cent novocaine is injected

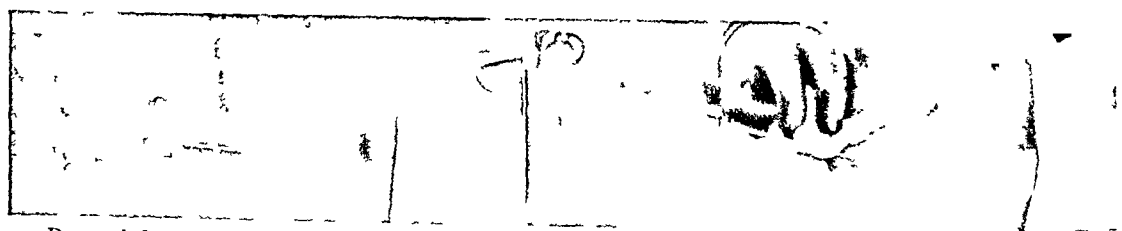


FIG. 2. Patient's head is turned to one side and extended, stretching sternocleidomastoid muscle. A  $4\frac{1}{2}$  in., 22 gauge needle is inserted through skin wheal and gently passed up just posterior to sheath of sternocleidomastoid muscle. Palpation of tip of needle through overlying skin helps to keep it superficial.

deep cervical plexus blocks. Although they produce a satisfactory anesthesia, they are difficult to execute and require multiple needle punctures into parts of the neck richly supplied by large blood vessels.<sup>1,2,4</sup>

## TECHNIC

A hypodermic of pantopon grain  $\frac{1}{3}$  and scopolamine grain  $\frac{1}{200}$  is given one

FIG. 3. About 15 c.c. of 1 per cent novocaine is injected while slowly withdrawing needle.

during the withdrawal of the needle. The needle should be kept in motion during injection to avoid intravenous injection of novocaine with its attendant dangers.

Anesthesia of the anterior three-fourths of the neck from the sternal notch to the tip of the chin is complete within five minutes. It is sufficient to permit thyroidectomy without pain, if the superior poles of the gland are infiltrated after exposure and before undue traction, clamping and ligation.

\*From the Division of Surgery, Jackson Clinic. Submitted for publication, December 18, 1929.

Superficial cervical plexus block, produced by the foregoing technic, has been used in 300 thyroidectomies at the Jackson

neck makes the patient more comfortable while lying on the operating table with the neck in hyperextension.

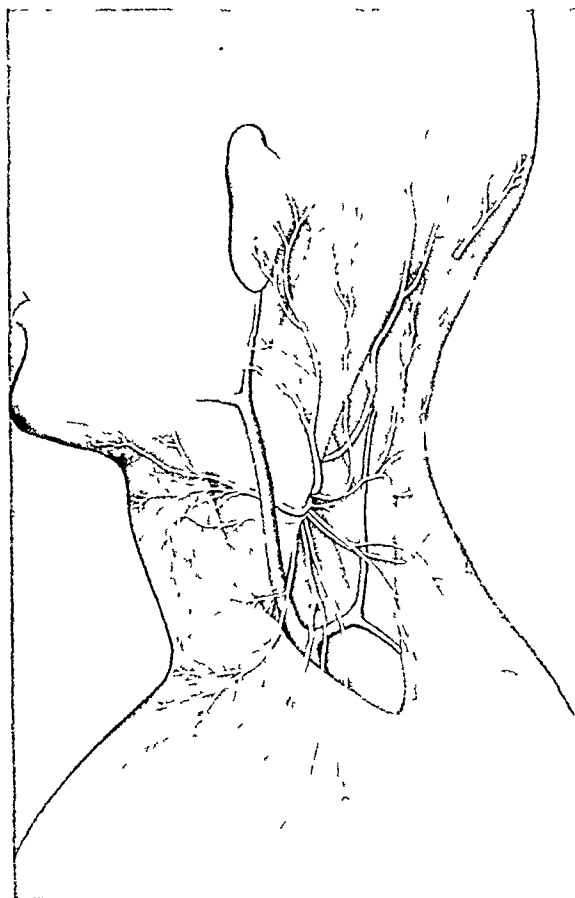


FIG. 4. Distribution of superficial cervical plexus. Shading indicates approximate area of anesthesia produced

Clinic with entire satisfaction. It also has been used for many other operations on the neck within the anesthetized area.

#### ADVANTAGES OF THE METHOD

1. The cooperation of a conscious patient is assured.
2. Undue vascular congestion is avoided.
3. Dissection of anatomically undisturbed tissues is easier than of edematous, infiltrated tissues.
4. Nerve block provides a complete anesthesia of a much wider and deeper area than is obtained by infiltration. Anesthesia of the lateral portions of the

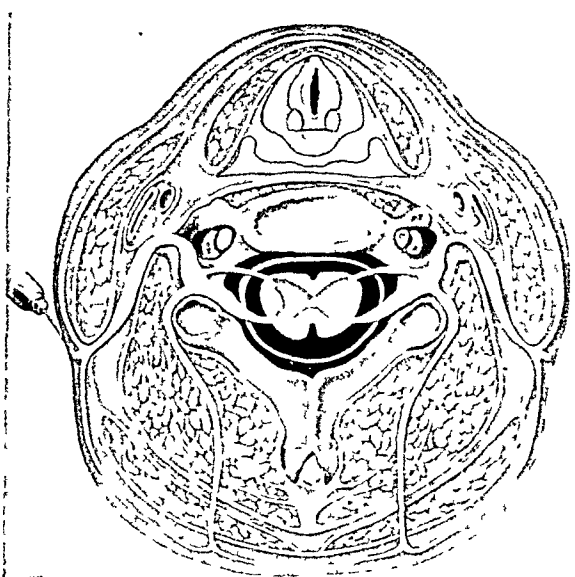


FIG. 5. Cross section of neck at level of fourth cervical vertebra showing point of injection. Anesthesia involves anterior three-fourths of neck. Deep anesthesia is not produced but it is unnecessary if preliminary pantopon-scopolamine is used.

5. Multiple needle punctures are avoided.

6. There is less danger of novocaine reaction from intravenous injection than with either infiltration or deep cervical plexus block.

7. Postoperative drainage is less profuse than with infiltration anesthesia.

8. The method is simple and easily mastered.

I wish to thank Dr. Arnold Jackson for his cooperation in the application of this technic to thyroidectomy.

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# RECTAL ANESTHESIA

## WITH TRIBROM METHYLALCOHOL\*

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RECTAL anesthesia was first advocated by Pirogoff in 1847 with subsequent reintroductions that were received with little or no enthusiasm, excepting perhaps Gwathmey's method of ether in oil colonic anesthesia. This lack of popularity was largely due to the high incidence of postoperative rectal irritation and certainly to the uncertain depth of anesthesia that was effected. There has, however, been recently elaborated by Dusenbergh and Willstatter, a new anesthetic compound, tribromethylalcohol, more popularly known as avertin.

Since the first presentation of this new anesthetic before the Berlin Surgical Society in 1925 by Butzengeiger, it has been used in over 250,000 cases that have been reported in the literature. This presentation will deal with the writer's personal experience covering a period of over three years, during which time the anesthetic was used in more than 600 cases. These cases will include a large number of anesthetics given during my association with Professors Sudech and Kummel, in the Surgical Clinic of the University of Hamburg, for a period of eighteen months, as well as several hundred given in this city since my original introduction of this anesthetic into the United States. It might be of interest to state that the first surgical procedure carried out under this anesthetic on this continent was performed by Dr. Joseph C. Beck of this city.

Tribromethylalcohol is a white crystalline substance with a melting point of about 79°C. to 80°C. It is readily soluble in water at 40°C. Its molecular structure is very labile and when heated above 45°C. it breaks down with a formation of a highly toxic and irritating substance, dibromacetaldehyde.

It was the presence of the dibromacetaldehyde in improperly prepared solutions, that caused large numbers of rectal irritations to be reported in the first year or two of its use. The presence of this injurious substance in a solution may be detected by the appearance of a blue color when a few drops of Congo-red are added. It should be stated at this time, that one should never employ a solution when it has been tested and found unsatisfactory.

Tribromethylalcohol is very rapidly absorbed; in fact 80 per cent of the drug is absorbed during the first twenty minutes of anesthesia, at which time, it reaches a concentration of about 7 mg. per cent in the blood. In its passage through the body, it is detoxicated by combination with glycuronic acid and excreted in this form by the kidneys.

Its toxic dose is in the neighborhood of about 0.5 gm. per kilo body weight and its anesthetic dose is in the region of 0.15 gm. per kilo body weight with a consequent therapeutic index of about 2, which is higher than any other anesthetics that are available. Recent work has shown that the toxicity subsequent to the combined use of avertin and ether was less than when either one of these agents was used alone. It has no effect upon the conjunctiva, cornea or gastrointestinal tract. It causes no damage to any of the parenchymatous organs and, in animals that have been subjected to over 100 anesthetic inductions over a short period of time, no changes of the parenchymatous organs were demonstrable. Indeed several animals during this investigation became pregnant and gave birth to normal litters.

Anesthesia, as might be deduced from the very rapid absorption into the blood,

\* Read by invitation before the Chicago Surgical Society, May 2, 1930.

occurs in a short period of time, as a rule in about seven minutes.

The writer's experience has been that unconsciousness may occur in as short a time as two minutes or an interval as long as twenty-five minutes may be required. This rapid induction is not attended by any excitation, the patient gradually becoming more drowsy and finally unconscious. The tendon and pupillary reflexes become weak and the pupils become contracted. However, this lack of reaction does not carry the same serious significance as it does with other anesthetics. The entire musculature of the body becomes relaxed. The pulse is little changed as to quality but its rate may be slightly increased. The systolic pressure falls about 10 to 20 mm. with little, if any change in the diastolic. There is a tendency for the restoration of a normal systolic pressure as the anesthetic progresses. The early fall may also be compensated by the use of ephedrine. Electrocardiographic studies during anesthesia showed no changes. The respirations are slower and shallower, but the respiratory efficiency is maintained by an increase in the tidal excursions. During anesthesia, an increase in the respiratory rate can be improved by carbon dioxide or lobeline.

#### PREPARATION AND ADMINISTRATION: PRELIMINARY MEDICATION

Any preliminary sedative or even none may be given. However, I have observed that morphine in larger doses than grain  $\frac{1}{6}$ , causes a greater interference with the already depressed respiratory center and therefore advise caution in its use. A preliminary cleansing enema is advocated, but this may be omitted in abdominal conditions that preclude its use.

The anesthetic is slowly dissolved in a solution of water at 40°C. so as to make a 3 per cent solution. The dose varies from 0.05 to 0.18 gm. per kilo body weight, the larger dose used in children. It has been the practice to reduce the dose in the presence of large abdominal tumors, ascites,

in kidney and pulmonary lesions, as well as in poor risks. As a rule a total dosage of 0.13 gm. per kilo body weight has given a satisfactory stage of anesthesia with pleasing surgical relaxation. In some instances an additional dose of 0.025 gm. per kilo was given when a patient failed to relax properly. A few cases would require the complementary use of a few drops of ether or a few whiffs of ethylene or any other anesthetic. Twenty per cent of my cases necessitated a complementary anesthetic as noted here. The patient had good surgical anesthesia which lasted from one and one-half to three hours, followed by a sleep of three to six hours. In addition to the rectal procedure, intravenous injection can also be used. Although I have used the intravenous method, I have not been impressed by any striking advantage. At this time, I might state that it is not my practice to give the entire dose at one time. The divided dose method that I have proposed, consists in giving half of the calculated dose and if sufficient anesthesia does not result, then I give half of the remaining dose and so continue giving half of the remaining dose until satisfactory anesthesia ensues. By this means, the additions of the anesthetics are smaller and smaller. The postoperative awakening is usually without incident and is comparable to awakening from an ordinary sleep. No nausea, vomiting or depression has been noted. About 10 per cent of my patients have complained of headache, which disappeared upon administration of pyramidon.

Broadly speaking, this anesthetic may be used in the entire domain of surgery and surgical obstetrics. Furthermore, it may be used in elderly patients, patients in debilitated states as well as in diabetes. It has been used in brain surgery, sinus surgery, pharyngeal operations, goiter, larynx, surgery of the chest and abdomen, as well as in gynecological, orthopedic and genitourinary procedures. Although various contraindications have been mentioned, only three have appealed to me.

Renal disease as a contraindication has been commented upon by various authors and since the kidney is the chief excretory organ of the anesthetic, caution is necessary in its use, although personally, I have performed nephrectomy with it.

Respiratory inefficiency is a definite contraindication, whether this be due to extensive pulmonary disease as tuberculoses, bronchiectasis or due to tracheal or laryngeal obstruction by tumor. This is due to the fact that the respiratory muscles are early inhibited by the anesthetic. I know of one fatality and two near fatalities due to the use of avertin in a case of laryngeal carcinoma, of extensive tuberculosis and of bronchiectasis respectively. Another contraindication is the presence of bleeding in the nasopharynx, as the protective pharyngeal and laryngeal reflexes are inhibited by the anesthetic. It is also contraindicated in an operation that may result in bleeding, such as tonsillectomy and adenoidectomy, nasopharyngeal tumors and sinus surgery. These contraindications are forcibly stressed and were brought to my attention by Drs. Joseph C. Beck and M. Reese Guttman.

#### MORTALITY

Although most authors have not reported any deaths from tribromethylalcohol, several have. Apparently the anesthetic risk that is intrinsic in this anesthesia is about 3 in 10,000. In the review of the literature, it is noted that the average death rates varies with the experience of the author. Those who report a series of cases of 1000 or more, show a death rate of 1.5 per 10,000. Those reporting in a series between 500 and 1000 show an average death rate of 3.5 per 10,000 and those reporting 100 or less, about 12 in 10,000. Furthermore,

most or many of the deaths were not attended by post-mortem examinations and may be that the anesthetic was unjustly incriminated. The most complete survey of deaths following avertin anesthesia has been made by Kirschner, von Nordmann and Killian. Killian concluded that the anesthetic was the cause of death in half of the series that was reported by him. Kirschner commenting on the same cases concludes:

1. In some of these cases no post-mortem examinations were made and these could be ruled out as questionable deaths due to the anesthetic.

2. Many of these deaths occurred in the early period in the introduction of tribromethylalcohol, as a general anesthetic. Consequently lack of experience resulted in overdosage of patients with the resulting death.

3. The severity of operation may have been the cause of death.

4. It can be readily observed that accidents due to avertin have decreased with an increase in the knowledge in the action of this anesthetic. Glasmer has recently made a reply to the report made by Killian in regard to avertin deaths in which some of these cases could not and should not be associated with tribromethylalcohol as the cause.

Von Nordmann in a general statement believes that the percentage of mortality has been less than with other anesthetics.

#### CONCLUSIONS

It appears that this drug will probably occupy a highly important place in surgical anesthesia. Although the last word on tribromethylalcohol has not yet appeared, it approaches the ideal anesthetic more closely than any other at our present command.



# AVERTIN BASAL ANESTHESIA

## CLINICAL OBSERVATIONS

### PRELIMINARY REPORT BASED UPON A STUDY OF 80 CASES\*

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ABOUT three years ago there was introduced abroad a new agent, known as avertin or tribromethanol, for the induction of general anesthesia by rectal administration. At present there is a wealth of German literature on the subject, and several papers have recently appeared in English medical journals.

The chemistry, pharmacology, dosage and technic of administration have been adequately discussed. The purpose of this paper is to report my experience in a limited number of cases in which approximately half the dosage necessary for surgical anesthesia was employed. The desired degree of anesthesia was attained by the supplemental use of inhalation anesthesia. Avertin should, in my opinion, be regarded solely as a basal anesthetic, the dosage being calculated for the individual patient so that a light narcosis, in itself harmless, is induced. This degree of narcosis assures to the patient practically all of the advantages that can be obtained by this method, while any disadvantages it may possess are minimized. Control of anesthesia is preserved by the supplemental use of the inhalation anesthesia. This permits the maintenance of any desired degree of anesthesia, which may be decreased at will to the point of the initial light narcosis. The best index as to the additional anesthesia required is the patient himself. Many of the undesirable characteristics of inhalation anesthesia are modified or eliminated by the use of this method of combined anesthesia.

The dosage of avertin used varied from 50 mg. to 100 mg. per kilo. of body weight, the average being 80 mg. Many factors influenced selection of the dosage. In extensive involvement of the liver or

kidneys, obesity, acidosis, cachexia, diabetes, anemia, shock, hemorrhage and in other conditions rendering the patient a poor risk, avertin was used in less than the average doses, if at all. On the other hand, a somewhat larger dosage was required by children, young adults, persons of the sthenic muscular type, alcoholics, hypersensitive patients, and those suffering from acute abdominal conditions. In general, therefore, individuals that are usually difficult to anesthetize by any method, received the larger doses, while the poor risks, the elderly or feeble, and those with low resistance were given the small doses. Many other factors were considered, such as the amount of preliminary morphine medication, probably duration and extent of operation, the possibility of profound shock or hemorrhage ensuing, the skill of the operator. In fact, it was believed necessary to consider every eventuality, since pharmacologically avertin is a cerebral depressant. If exhaustion occurs from any cause, the depression of circulation and respiration produced by excessive doses of avertin becomes clinically evident; hence the use of a small dosage in order to remain well within the limits of safety.

The advantages of avertin anesthesia are many. The technic of administration is simple. There is an easy and pleasant stage of induction. The patient soon becomes drowsy and falls into a deep sleep with no unpleasant sensations; loss of consciousness is usually complete in ten minutes. The stage of recovery is equally calm, and many patients require little or no postoperative morphine medication, since the hypnotic effect of the drug wears off quite slowly.

Avertin is administered to the patient in his room, in which he goes to sleep and

\* Submitted for publication, March 8, 1930.



later awakes, so that he remains unaware of the journey to and from the operating room. There is no stage of excitement or of muscular rigidity. The maximum narcotic effect is attained in from twenty to thirty minutes. Even when the dose is so small that consciousness is partially retained, the entire mental outlook is altered, apprehension is eliminated, and little if anything is remembered, because of the characteristic retrograde amnesia.

The individual variations in susceptibility are as pronounced with avertin as with other anesthetics. Withdrawal is impracticable. The degree of narcosis obtained with it determines the required amount of gas or ether, which may be augmented safely to the desired level of anesthesia, and later rapidly withdrawn. The combination of avertin with inhalation anesthesia seems to produce results unattainable with a single general anesthetic agent, and complies with Lundy's principle of a balanced anesthesia. It is possible to vary widely the percentage of oxygen in the gaseous mixture. For the more extensive intra-abdominal operations, ether was preferred to gas. In their influence upon the rate and amplitude of respiration, ether and avertin, in moderate amounts, are direct opponents, but both act in the same direction in securing anesthesia. With ethylene the respirations are likely to be slow and shallow; with nitrous oxide, more rapid and deeper; with ether, the rate and depth are also increased.

With patients having a tendency to cyanosis, not of mechanical origin, ether given by the drop method on the open mask acts as a respiratory stimulant, as does carbon dioxide and oxygen. Cyanosis does not necessarily indicate either an excessive degree of anesthesia or a mechanical obstruction. In rare instances, it may be due to direct action of avertin on the respiratory center and may be present with anesthesia insufficient for surgical purposes. Carbon dioxide and oxygen act well as a respiratory stimulant in light anesthesia and increase blood pressure,

but are less effective after anesthesia deepens. The transient depression of respiration and circulation is also relieved by such operative manipulations as incision of skin, exploration of abdomen, etc. Most patients do as well without as with morphine, which acts similarly upon the respiratory center as avertin. For this reason, patients who receive both may occasionally manifest severe respiratory depression. Accordingly, avertin should not be given after heavy preliminary morphine medication. The systolic pressure may drop about 15 mm., then ascend slowly almost to its previous level, which is maintained unless influenced by other factors. In avertin narcosis the masseter muscles relax early and remain so for a long period. Salivation and bronchial secretions are inhibited.

When avertin is used as a basal anesthetic, the vomiting and respiratory spasm sometimes provoked by surgical procedures are absent. In fact, the patients cannot be made to vomit, the probable reason being that the function of the vomiting center is suspended. Recovery of the function of the vomiting center is gradual and too late after the operation to cause post-operative vomiting. However, if the nature of the operation or the condition of the patient is such as to exert a continuous stimulus upon the center, vomiting may recur after ten or twelve hours; this has happened after some intestinal operations, gastroenterostomy or cholecystectomy, and after operation for ruptured appendix with peritonitis, etc.

Some degree of muscular rigidity is often present when nitrous oxide is used, especially on closure of the abdomen, but with ether in small amounts relaxation is excellent. During an upper abdominal operation, if muscular rigidity and anoxemia occur due to traction or manipulation, no hesitancy need be felt in using ether to overcome this condition; it acts advantageously in deepening the respirations, relaxing the abdominal muscles and improving the patient's color.

I have observed in adults who are difficult to anesthetize (particularly men of muscular physique) and in one child of eleven years, a convulsive paroxysm upon withdrawal of the supplemental gas anesthetic. The clinical manifestations are those of a severe chill with rigidity of the abdominal muscles, opisthotonos, spastic contraction of the arms and clenching of the jaws. The attack is analogous to the recovery of the deep reflexes following other anesthetics and, while it is somewhat alarming, passes off in a short time and need not cause anxiety. It indicates that the patient is likely to recover from the anesthetic sooner than usual. With one exception, it was not noted when ether was used; in fact, a few breaths of ether on the open mask will relax the spasm. Rarely does a patient during recovery become excited; a hypodermic of morphine will quiet such a patient and enable him to secure several hours of sleep.

Clinical and pharmacological observations indicate that the period of anesthesia with avertin may be shortened, and blood pressure and respiration improved by the use of caffeine sodium benzoate. This drug has proved effective in interrupting the narcosis in laboratory animals, and at present seems the most promising for this purpose. It is probably useless to give less than  $7\frac{1}{2}$  to 15 grains of caffeine sodium benzoate to any patient requiring stimulation; it is safe to use large doses in such cases.

In moderately severe hyperthyroid types, the average dosage of 80 mg. per kilo appears to be well tolerated. In my opinion, its use is especially indicated in this and allied conditions. However, if the surgeon desires to test the phonation during the operation, the dosage of avertin should not exceed 60 mg. per kilo when supplemented with gas. This will usually secure the desired results. In ophthalmic surgery or whenever the patient must remain absolutely quiet, ether is preferable to gas as a supplemental anesthetic.

Patients who are difficult to anesthetize with gas, will respond more easily to avertin and gas; the administration of the latter may be varied within wide limits, without fear of vomiting or respiratory spasm. When avertin is supplemented with ether, the stage of excitement is absent, muscular rigidity is often so transient as to be hardly noticeable, and salivation or bronchial secretion fails to occur. A slow regular drop by the open method is sufficient in most cases. Usually, only a small quantity is necessary. When satisfactory relaxation has been secured, the ether may often be discontinued, or a small amount may again be administered just before closure of the abdomen. Relaxation, once obtained, lasts for an appreciable interval after the withdrawal of ether. If ether is to be used as the supplemental anesthetic, the dose of avertin may generally be reduced.

During the stage of recovery, which may last from one to three hours, the patient should be watched continuously by an attendant. As mentioned before, the masseter muscles are relaxed, the tongue and jaw dropped, and the pharyngeal reflexes diminished; failure to insure an open airway at all times may result in asphyxia. To prevent respiratory difficulty from mechanical obstruction, an airway may be inserted as soon as the pharyngeal reflex is abolished, and left in place during operation and the postoperative period.

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# AVERTIN ANESTHESIA IN OBSTETRICS\*

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**T**RIBROMETHYLALCOHOL or avertin, which has had wide usage abroad in surgical cases is now available for obstetric work in America. Being a rectal anesthetic it obviously has many advantages.

Avertin is a white crystalline powder which is readily soluble in water at a temperature of 104°F. at which temperature the solution should be maintained if possible. Light and air must also be excluded.

Absorption by the bowel is quite rapid. Eighty per cent of the drug is taken up in the first twenty minutes (Straub). In fact the chemical imbibition is much faster than the water in which it is dissolved. This circumstance is of great value in the case of ignorant patients who have a tendency to expel the fluid.

Elimination occurs through the kidneys by combination with glycuronic acid and for this reason it seems wise at present to avoid the use of avertin where the kidneys are damaged.

Toxicity need not be feared until about  $3\frac{1}{2}$  times the therapeutic dosage is exhibited so the latitude of safety is adequate. In combination with ether in the proportion of 1:1 or of 2:1 the anesthetic effect of both is increased and the lethal danger diminished.

The drug is dissolved in water at a temperature of 104°F. so as to make a 3 per cent solution. Hertzberg recommends a gum acacia solution as less irritating to the bowel. The temperature must not rise above 104°F. or the substance will decompose and liberate dibromacetaldehyde which is markedly irritating to the intestine and often destructive. Each usage requires fresh preparation therefore and each preparation must be carefully tested by adding 2 minims of a 1:1000 solution of Congo-red to every 5 c.c. of avertin. If the color is

a clear orange red the solution is right. If it turns blue, free hydrobromic acid is present and the mixture must be discarded.

In our 10 cases 7 women were multiparas and 3 primiparas. Two of the labors were induced.

The dosage for anesthesia ranges from 0.1 gm. to 0.15 gm. per kilo of body weight. In our trials at the Wesley Maternity we used only .05 to .06 gm. per kilo of body weight and so obtained a narcosis in place of an anesthesia.

The administration was begun in our service when the dilatation was practically complete. The technic requires the introduction of a tube into the rectum above the advancing head, and through this the fluid is passed to the colon. Gravity is usually sufficient if the container is high but in some instances the head occludes the tube by pressure and a piston syringe is required.

The effect of the drug is said to begin in fifteen minutes and last for two hours. In our women the effect was evident in fifteen minutes and the average duration was one hour and fifty minutes, for 9 of the cases. One woman had 2 injections and the duration of the narcosis was four hours and thirty minutes.

The results of the narcosis in general were excellent. One patient got no relief. Nine women had no recollection of pain though in 2 cases the fluid was partially expelled. One woman stated that she felt as if a fish was sliding out of her. No preliminary excitement was observed and the awakening was as gentle as from a normal sleep. No headache or vomiting followed the narcosis.

During the narcotic period the pulse varied from 2 to 8 beats, the blood pressure shifted from 5 to 10 points and the respiration from 2 to 4 excursions in observations

\* Submitted for publication April 23, 1930.

made at intervals of fifteen minutes. None of these changes was greater than one may find in normal labors from uterine activity alone.

In 3 instances the pains were slowed up somewhat but in no case were the contractions seriously affected or the evolution of the third stage influenced. In 2 of the labors 15 drops of ether were given as the head passed the perineum and in another the same amount was administered for the perineal repair.

Nine of the babes cried lustily as soon as delivered. The tenth patient, with a history of no heart tones on prenatal examination, delivered a macerated fetus.

In one woman there was a slight excess

of mucus expelled from the bowel a few hours after delivery.

The observers of these cases are ready to believe that the absorption of the avertin will definitely mitigate the pains of labor in most instances, that used in narcotic doses it interferes but very slightly with the contractions and that it does not appear to pass over to the baby. From so small a number of cases no opinion can be final but the impression given in the clinic is that the drug is easy to use and with ordinary care as a basic anesthetic it is safe for the mother and will give great relief to those high-strung women who have strong contractions which they retard by fear and resistance.



# TRIBROMETHYL ALCOHOL IN OTOLARYNGOLOGY\*

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FEW specialities can have less reason than the otolaryngological to be satisfied with their methods of anesthesia. In 1925<sup>1</sup> I reviewed the methods of local and general anesthesia, emphasized their shortcomings and made a plea for rectal anesthesia in major surgical procedures about the head and neck as a means of placing anesthetic methods on a more accurate, rational and convenient basis. The justification for the employment of rectal methods of administration of anesthetic agents in our speciality is based upon the fact that we would minimize the manipulations of too many hands in an already small operative field and thereby not transgress the rigidly aseptic technic which many of our procedures demand. Since anesthesia is never likely to become an exact science, there is a great need for a form of rectal anesthesia on an agreed basis that will yield uniformly good results which will be comparable wherever obtained.

In our specialty, whenever anesthesia is mentioned, whether it be local or general, the question regarding both operative and postoperative complications is the paramount issue. Local anesthesia has been the choice of practically all rhinologists mainly because of the simplicity of administration and because of a possible greater margin of safety. In recent years, however, one is forcibly struck by the numerous reports in the literature of the toxic effects of the various local anesthetic agents, with the resultant fact that one must of necessity feel the uncertainty regarding this possible margin of safety. It is commonly accepted by all that general anesthesia used for operations about the nose and throat predisposes to the development

of pulmonary complications but we also know that such complications can be secondary to general anesthesia when given for abdominal procedures or even following operations done under local anesthesia. It is generally conceded that infection may travel either by the lymphatic or the cardiovascular system or by direct extension into the tracheobronchial tree. Just at this time there are mainly two groups, one holding that the infection is embolic and the other that aspiration is the only possible way. Both schools of thought offer facts to substantiate their particular side of the question. It is not the object of this paper to discuss the pros and cons of either side, the point being relative to the uncertainty of the so-called perfected methods of local and general anesthesia.

There is no doubt that anesthesia, properly conducted, is distinctly a science, and as such should occupy an important place as a specialty in this broad field of medicine. Therefore, we would say that complications and mortality rates are not always an indication of the toxic or harmful effects of the anesthetic agent used; but by careful analysis in many instances one would find causative factors in a lack of the fundamental knowledge concerning indications and technic of administration. Then, too, such factors as operative risk, with reference to the individual patient, operative technic, and postoperative care are often forgotten and yet are fundamental in increasing the coefficient of safety of any anesthetic agent. Too often are methods thrown into discard because of improper application or lack of attention to the finer details of technic.

In 1923<sup>2</sup> I published a preliminary report on the method of synergistic analgesia as

<sup>1</sup> LEDERER, F. L. (with Beck & Pollock) Further report on synergistic analgesia. *Laryngoscope*, 35: 181-199, 1925.

<sup>2</sup> LEDERER, F. L. Synergistic analgesia. *AM. J. SURG.*, 38: 80-88, 1924.

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proposed by Gwathmey, and later, in 1925, reported on another larger series of cases an improved technic of administration of this mode of rectal analgesia. The shortcomings of the synergistic method are only too apparent; namely the uncertainty of dosage, lack of uniform results and disconcerting sequelae. It is not unusual therefore that our interest should have been aroused when our attention was called to tribromethyl alcohol as an anesthetic agent. During the past year we have been working with this preparation known commercially as avertin. While this preparation was at first recommended to us as a basal anesthetic, we have been engaged in an extensive study of many cases to establish the dosage as a surgical anesthetic. As a basal anesthetic, the noticeable fact has been the small amounts of ether or other supplementary anesthetic agents that were required to induce muscular relaxation. We find that in our surgical procedures about the head and neck and especially the upper respiratory tract there is a distinct advantage to this form of anesthesia. Moreover, rectal anesthesia is definitely indicated in surgical cases where in the patient is suffering from respiratory embarrassment (except of an obstructive character) or where the amount of absorption of anesthetic agents must of necessity be limited because of lung, heart or kidney lesions.

It is not the object of this paper to analyze critically and differentiate the various anesthetic agents on the basis of merit but rather to stress the value of this type of anesthesia in our field as one of the valuable adjuncts in the work. In our practice rectal anesthesia has always been popular and tribromethyl alcohol has proved itself practically easily administered and efficient. We would not be so dogmatic as to say its use is not the least bit fraught with danger but attention to the small almost insignificant details certainly will minimize any mishaps. I mention this merely because one sees such mishaps reported in the literature for which the

anesthetic agent in most instances has been blamed, whereas the fault often lies with the other factor already mentioned. The use of any drug, even ether, was not meant for the tyro or inexperienced anesthetist and therefore it was our desire to proceed with our observations on a carefully controlled scientific basis.

Our technic of preparation of tribromethyl alcohol is the standard method recommended by other clinicians who have been working in this field and is summarized as follows:

*Preparation of the Patient:* Accurate weight (in kilograms) is obtained for the purpose of governing the dosage. Laxative or enema; sedative such as veronal, the night before to insure rest.

*Preoperative:* In cases where patients are of a nervous disposition or where difficulty is anticipated, morphine sulphate  $\frac{1}{4}$  grain is given about two hours before the administration of tribromethyl alcohol.

*Dosage:* Given according to the patient's body weight (in kilograms) and according to the general condition, 125 mg. per kilo being the average dosage which was found to give the best results. In children the dosage was raised to the same amount per kilo of body weight because 100 mg. was found to be insufficient.

*Preparation of the Solution:* One c.c. of the avertin fluid equals 1 gm. of tribromethyl alcohol. Measure the dose of the fluid with a pipette graduated in tenths of a cubic centimeter. Heat the amount of distilled water necessary to make a 3 per cent solution to 40°C. (104°F.). Add the avertin fluid, dissolve by vigorously agitating and make sure that the material is actually in solution and not in suspension. Furthermore the mixture is tested by placing 1 or 2 c.c. into a test tube and adding two drops of 1:1000 aqueous solution of congo red; the resulting color under normal conditions being a clear orange red. If a change of color to blue occurs the presence of a free dibromi-acid alcohol is indicated and therefore the solution should not be employed as it is decomposed. Severe

irritation to the rectal mucosa results from a decomposed solution.

**Administration:** The injection of the 3 per cent tribromethyl alcohol solution at body heat is given as a retention enema either by gravity or gentle syringe pressure with the patient over on his left side, taking about five minutes for its introduction. Narcosis begins with drowsiness and takes place in from five to ten minutes. Suitable environment in a quiet and darkened room is desirable; and wherever possible, in the patient's own room.

**Anesthesia:** The patient is surgically anesthetized in from fifteen to thirty minutes and should be transported to the operating room with the least possible manipulation.

**Supplementary Anesthesia:** In some instances where the patient does not seem to be sufficiently anesthetized small doses of inhalation anesthetics may be indicated. It must be borne in mind that very little supplementary inhalation anesthesia is necessary to hold these patients surgically asleep. In some cases topical application or infiltration of local anesthetics is sufficient to supplement avertin as a basal anesthetic. We have not employed supplementary doses of avertin believing it to be an uncontrollable factor.

**Postoperative:** The noticeable factor has been the few cases wherein it was necessary to use postoperative analgesics. The time of sleep varied from a few hours to ten hours with a secondary sleep carrying the patient comfortably through the night. We have at the completion of our operative procedures often washed out the rectum, this despite the fact that we know the majority of the drug has been absorbed.

We do not feel that in this form of anesthesia we have replaced either the anesthetist or the nurse. The patient is to be watched closely especially as to the dropping of the jaw, there being such complete relaxation. The respiration is slower and more superficial, and in some instances the skin assumes a clammy appearance. In the majority of our cases the color has been

#### TYPICAL AVERTIN RECORD

Case 15

Date Sept. 17, 1929

Patient: Wm. M. Age, 19. Weight 62.4K. Sex Male  
Diagnosis: Chronic Suppuration of left maxillary sinus  
Preoperative Medication: Morphine Sulphate  $\frac{1}{4}$  gr.  
Amount of Avertin: 8 Gram. Amount of Water 268 c.c.  
Time of Injection: 1:35-1:40. P.M. Time Beginning  
Narcosis 1:55 P.M.

Time: 1:30 P.M.	Pulse 98.	Resp. 24	B.P. 150/90 P.M.
2:45 P.M.	95	24	150/90 P.M.
3:00 P.M.	95	24	150/85 P.M.
3:15 P.M.	95	24	142/85 P.M.
3:30 P.M.	98	28	150/85 P.M.
3:45 P.M.	85	26	142/90 P.M.

Time Operation begun: 2:55 P.M. Time Operation Ended 4:00 P.M.

Supplemental Anesthetic none

Time of Awakening: 10 P.M. Duration Secondary Sleep 8 hours

Character of Awakening As for normal sleep—didn't know he was operated

			Differential		
Blood	R.B.C.	W.B.C.	P.	L.	M.
Before	6,848,000	16,600	65	28	7
1 hour after	6,720,000	14,000	66	30	4
24 hours after	6,540,000	16,200	68	26	6

Remarks: Left Radical Antrum (Luc-Caldwell) performed. Slight motions during operation but at no time were the motions sufficient to disturb the operator. No unusual bleeding.

normal throughout and only in cases of marked laryngeal obstruction have we noted cyanosis. This difficulty arises mainly because the glottis is narrowed and with the respiration slower and shallower the bellows action of the lungs is insufficient to force air through this chink.

Occasionally patients have complained of pain during operations or remonstrated in one way or another but upon awakening in answer to questions would recall nothing relative to pain or to conversation that took place. Perhaps the best recommendation for an anesthetic is the patient's own acceptance or reaction to this form, and this is especially true in cases where patients have previously experienced different types of anesthesia. In a number of instances patients have stated to us that this anesthesia was the most tranquil they have ever experienced; moreover, in several patients we had known them to be poor subjects to every other form that was ever tried.

Tribromethyl alcohol cannot be considered entirely experimental, since it has been used in Europe and in this country in more than 250,000 cases of surgical procedures of all kinds. The only contraindications that were known to us were certain diseases of the liver and rectum and advanced tuberculosis. Nevertheless we have been cautious in the selection of our cases excluding the elderly, debilitated and dehydrated individuals and patients with dyspnea due to laryngeal obstructions. We have used it in diabetics when the choice of the anesthetic left us in doubt. We have been fortunate to observe a number of cases which had previously responded very poorly to other anesthetic agents both local and general where avertin had proved its worth. Our cases have all been carefully studied and controlled by clinical and laboratory observations. Young children from the age of six, and adults up to the age of seventy, have comprised

our series. It was quite noticeable that sleep was quickly and quietly induced, there being no stage of excitement, and while the respiration was shallow the entire period of sleep was tranquil. The patient awakes in a few hours and remembers nothing of the operation and the secondary sleep is quiet and seldom required analgesics for pain. After effects in the way of nausea, vomiting, headaches or abdominal discomforts are totally absent and we have never observed any outward effects due to rectal irritation. We are still at work perfecting the technic and it will be interesting to watch the unbiased reports of others as to the usefulness of tribromethyl alcohol as an anesthetic agent in our field. While we realize that there will be here and there reports of difficulties with this form of anesthesia we feel that the genuine pleasure of the results of the use of this agent warrants the lending of every effort to its use.





# EFFECTS OF AVERTIN ON LIVER FUNCTION:

THE RATE OF SECRETION AND COMPOSITION OF THE URINE, THE REACTION,  
ALKALI RESERVE AND CONCENTRATION OF THE BLOOD AND  
THE BODY TEMPERATURE\*

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AVERTIN (tribromethyl alcohol) was first prepared by Willstätter and Duisberg<sup>1</sup> in 1923, but it was not until 1927 that Eichholtz<sup>2</sup> first demonstrated its anesthetic properties. Since then avertin has been used widely in Germany: Spiegel<sup>3</sup> states that more than 80,000 cases have been reported to date. The pharmacological investigations of Eichholtz,<sup>2,4</sup> Straub,<sup>5,6</sup> Parsons,<sup>7</sup> Welsch<sup>8</sup> and many others concern the action of avertin on the circulation and respiration, the rate of absorption and excretion and its toxicity. Following upon our work on sodium amytal,<sup>9</sup> we have studied in a like manner the effects of avertin on liver and kidney function, the reaction, alkali reserve and concentration of the blood and the body temperature.

These observations were made on the dog and man. In the first experiments the dogs received 500 mg. of crystalline avertin per kilogram of body weight in 3 per cent aqueous solution per rectum. The solutions were always freshly prepared, were never heated above 40°C., and were always tested for decomposition products with congo red. The use of this dose of crystalline avertin in dogs gave us no trouble. Later, we began using avertin fluid (which is a 100 per cent solution of avertin in amylene hydrate) in the same dose and with the precautions mentioned. With this preparation, in 3 cases out of every 5, within five to ten minutes after the rectal infusion there was complete cessation of respiration and the dogs became markedly cyanotic. The heart, however,

would keep on beating for some time. Inasmuch as we wished to avoid cyanosis as much as possible and, of course, fatalities, in these cases air at a low pressure was administered by means of a rubber tube introduced into the trachea; by compression of the trachea about the tube from the outside the lungs could be expanded at will. By this means we were successful in a large number of cases in maintaining a good color, but even this procedure in a small number of instances proved unsuccessful and the animal died. In those cases in which there was respiratory depression with marked cyanosis but in which respiration did not cease entirely, artificial respiration was administered manually. We thought that the dogs might have been dehydrated, thus favoring unusually rapid absorption of the drug; to offset this, 100 c.c. of water by stomach tube for every 3 kg. of body weight was given from one half to two hours before the administration of avertin. This was tried in 3 cases without success. The dose was then reduced to 400 mg. per kilogram of body weight and although the respiratory depression was less marked, there was still trouble in maintaining a good color. It is evident, therefore, that avertin fluid is far more effective than the crystalline substance, that the recommended dose of 500 mg. per kilogram for the dog is altogether too high when avertin fluid is employed, and that the state of hydration of the tissues does not influence its toxicity.

Harnack and Meyer<sup>10</sup> have shown that

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amylene hydrate at first stimulates and then depresses the respiratory center. We have never noticed any respiratory stimulation when avertin fluid was used. On the contrary, we are convinced that the respiratory depression is more marked with the fluid than with the crystalline substance.

TABLE I  
AVERTIN ON LIVER FUNCTION

Experi- ment No.	Dose per Kg., Mg.	Time Blood Withdrawn following Avertin Administration, Hours	Dye Retention, Per Cent
1	500	24	30
		48	10
		90	10
2	500	24	5
		48	5
3	500	24	15
		67	5
4	400	24	25
		48	10
		72	10
		114	5
5	500	48	5
		72	5
6	500	48	5
7	500	24	5
		48	5
8	500	24	5
		48	- 5
9	500	24	10
		48	-10
		72	5
10	500	24	-5
		48	-5
11	400	24	-10
		48	-10

Human

- 1. Male. 59.1 kg. Herniotomy. 100 mg. per kg. avertin fluid. Nitrous oxide and oxygen for 20 minutes. One-fourth grain morphine postoperatively. No dye retention in 24 hours.
- 2. Male. 48.6 kg. Herniotomy. 100 mg. per kg. avertin fluid. Nitrous oxide and oxygen for 30 minutes. No morphine before or after. No dye retention in 24 hours.

In man, 100 mg. per kilogram of body weight was the dose of avertin fluid employed in 3 cases. No untoward effects were noted.

LIVER FUNCTION

The method employed for testing the function of the liver was that of Rosenthal and White,<sup>11</sup> which depends upon the removal of bromosulphalein from the blood by the liver. The results are shown in Table 1. In the dog, 11 observation were made. Nine received 500 mg. and two 400 mg. of avertin (crystalline substance or fluid) per kilogram of body weight. It will be seen that the drug produces slight and transient but no delayed liver damage. In only 3 cases was there more than 10 per cent dye retention after twenty-four hours. Normal animals show less than 5 per cent retention of dye. In 2 human cases (done at the Western Division of the Montreal General Hospital) there was no dye retention twenty-four hours after the administration of 100 mg. of avertin per kilogram of body weight.

The results show that so far as hepatic function is concerned, avertin compares well with amytal<sup>9</sup> and the inhalation anesthetics,<sup>12,13</sup> the damage produced to the liver being negligible.

RATE OF SECRETION AND COMPOSITION OF THE URINE

Five experiments were conducted on dogs with bladder fistulas according to a method devised in this laboratory.<sup>14</sup> The urine was collected as it was secreted, urea determined by the method of Stehle<sup>15</sup> and phosphorus by the method of Pregl.<sup>16</sup> Tables II and III are examples of the results obtained. In every instance the animal received 500 mg. of avertin per kilogram of body weight by rectum. Anuria always occurs immediately after its administration and lasts for a period varying between fifteen minutes and one hour, after which marked oliguria occurs. The absolute output of urea is always lessened for four

TABLE II  
BLADDER FISTULA DOG NO. 1  
Weight 7.7 kg.

11.00 A.M.—200 cc. water by stomach tube

Urine

Time	C.c. per Min.	Mg. Urea per Min.	Per Cent Urea	Mg. P per Min.	Per Cent P
2 30- 3.30	.160	5.246	3.279	.083	.0517
0.5 gm. per kg. avertin crystals in 2.5 per cent solution per rectum (3.85 gm. in 154 c.c. water). Anuria for 25 minutes.					
3.59- 4.59	.100	2.732	2.732	.091	.0909
4.59- 5.39	.215	5.100	2.372	.232	.1079
9.05- 9.55 (next day)	.182	7.794	4.283	.680	.3736
10 10-11.10	.057	4.320	7.624	.171	.3026
2.30- 3.30	.100	5.128	5.128	.178	.1783

to six hours following the administration of the drug. The percentage excretion, however, is usually increased or only slightly lessened. Within eighteen to twenty-four hours the absolute output is approximately normal and the percentage is much above the control figures.

TABLE III  
BLADDER FISTULA DOG NO. 3  
Weight 10.8 kg.

11.30 A.M.—200 c.c. H<sub>2</sub>O by stomach tube

Urine

Time	C.c. per Min.	Mg. Urea per Min.	Per Cent Urea	Mg. P per Min.	Per Cent P	Remarks
3.15- 3.45	.643	7.482	1.163	.191	.0297	Marked respiratory depression following administration of avertin.
5.4 c.c. avertin fluid in 180 c.c. H <sub>2</sub> O per rectum (500 mgs. 1 kg.). Anuria for 47 minutes.						
4.27- 5.27	.123	1.854	1.504	.149	.1209	
5.35- 6.35	.148	3.592	2.422	.160	.1076	Air intratracheally for 1½ hours.
8.56- 9.26 (next day)	.253	7.335	2.895	.800	.3159	
10 18-11.18	.081	5.040	6.171	.133	.1630	
3.45- 3.45	.095	5.165	5.436	.165	.1735	

Phosphoric acid excretion is generally increased, both in minute rate and percentage output. The maximum excretion of phosphoric acid takes place from six to twenty-four hours after the administration of avertin; in only one instance did this occur in the first two hours.

Two observations were made on man at the Western Division of the Montreal

General Hospital. The bladder was emptied and washed the evening before the operation. The urine passed thereafter was kept and added to that obtained at the next catheterization, just before the administration of the drug. Catheterization was repeated shortly after the operation and again twenty-four hours later. Table iv gives examples of such a case. In a general manner, the results obtained resemble those obtained with dogs.

TABLE IV  
MR. D. AGE FORTY-NINE. WEIGHT 59.1 KG.  
Herniotomy

Urine

Period	C.c. per Min.	Mg. Urea per Min.	Mg. P per Min.
Control (12-hour sample).....	1.09	10.570	.5515
5.91 c.c. Avertin fluid in 200 c.c. water by rectum (100 mm. per km.)			
Anesthetic (2 hour sample).....	.30	3.012	.3618
Postanesthetic (22 hour sample).	.44	7.568	.7169

It is obvious that the anuria which always follows avertin administration must either imply kidney depression or be due to a fall in blood pressure. The use of bladder fistula dogs does not lend itself to simultaneous determinations of urine flow and of blood pressure; nevertheless, it is evident from the protocols that the kidney is unable to concentrate urea for a time as much as normally. There is no doubt that kidney function is more depressed with avertin than with amytal;<sup>9</sup> in this it resembles ether<sup>17-19</sup> but the depression is transient and the kidney soon recovers, usually within four to six hours.

The human cases received only one-fifth of the dose given to dogs. The results obtained indicate that there is no evidence of severe kidney depression, inasmuch as urea was fairly well concentrated during the anesthetic period.

As has been found in the case of amytal, avertin produces blood dilution in the great majority of the cases. This would ordinarily be expected to cause an increased

urine flow. It is probable that oliguria occurs, in spite of the hydremia, because of the kidney depression or as a result of the lowered blood pressure.

The increase in phosphoric output which occurs following the administration of amytal, ether and, as we have now shown, avertin, is (as in the case of the former two) probably involved in the acidosis now to be described.

#### THE REACTION AND ALKALI RESERVE OF THE BLOOD

The carbon dioxide combining power of the plasma was determined by the method of Van Slyke and Cullen<sup>20</sup> and the pH values by that of Dale and Evans.<sup>21</sup> Table v shows the results obtained. It will be seen that following the administration of avertin the blood bicarbonate increases slightly in most cases for half an hour and then falls below the control figure. In one-third of the cases it fell from the start, but never to a marked degree. In 6 out of 8 cases the hydrogen-ion concentration of the blood increased, the pH values falling 0.1 to 0.2 units. In one instance the pH remained unchanged and in another there was a slight decrease.

As we have noted previously, in the greater number of experiments there was marked depression or complete cessation of respiration, involving, doubtless, an increase in the carbon dioxide tension of the blood. This may have been compensated for by a migration of base into the blood, thus accounting for the slight increase in blood bicarbonate. As the breathing became more depressed and artificial aids to respiration were employed, a considerable amount of the carbon dioxide may have been blown off from the lungs, resulting in a return of base to the tissues. This would account for the later fall in blood bicarbonate below the control figures. Thus, it will be seen from Experiment 10, Table v, in which pure oxygen was administered intratracheally but in which no artificial respiration was employed, a good color was maintained throughout the

experiment and there was little change in the bicarbonate content of the blood.

The results indicate, therefore, that avertin does not affect the carbon dioxide combining power of the plasma to any considerable extent, provided there is no marked respiratory depression and a good color is maintained throughout the period of anesthesia.

Our pH determinations, on the other hand, point to a mild acidosis in the great majority of cases of the order found with amytal and ether. Like the latter two, it is also associated with an increase in the phosphoric acid output and we think that here too the disturbance in phosphoric acid, and possibly lactic acid metabolism, may play a part in the acidosis.

Koehler, Brunquist and Loevenhart<sup>22</sup> have shown that anoxemia produces a more marked acidosis than has been observed in any other condition, and it is probable in the case of avertin that the profound degree of anoxemia due to the respiratory depression may play an important part in the production of the acidosis. Nevertheless, a careful study of our protocols will show that a mild degree of acidosis has occurred in those animals in which little or no cyanosis was present.

#### BLOOD CONCENTRATION

Blood solids were determined by weighing a small amount of blood, as drawn, before and after drying to constant weight at 110°C. Table iv includes 8 such experiments. In 6 out of the 8 cases, there was a definite degree of blood dilution, especially in those instances (Experiments 4 and 6) in which the dogs received water by mouth before the avertin administration. In most cases, after two hours there was a slight degree of blood concentration, which is in keeping with the observation that the dogs drink water freely after recovering from the effects of the anesthetic. In this respect, avertin resembles amytal, both drugs producing a slight hydremia. The blood concentration and marked thirst observed with avertin one

TABLE V

Ex- peri- ment No.	Dog No.	Weight in Kg.	Water by Mouth	Dose of Avertin per Rectum	Remarks	Period, Hours	Blood Solids, Per Cent	pH	CO <sub>2</sub> Comb. Power of Plasma in Vols., Per Cent	Rectal Temp., °C.
1	B1	28.0	.....	14 c.c. avertin fluid in 466 c.c. water (500 mg. per kg.)	Respiratory cessa- tion. Air intra- tracheally for 30 minutes	Control	22.76	....	44.8	38.7
						$\frac{1}{2}$	24.65	....	48.4	
						1	22.49	....	44.2	35.7
						2	23.64	....	41.0	36.5
2	B2	25.2	.....	12.6 c.c. avertin fluid in 420 c.c. water (500 mg. per kg.)	Resp. cessation. Air intratracheal- ly for 1 hr. Dog stuporous for 2 days. Died in 3 days from bron- chopneumonia	Control	21.27	7.50	50.9	39.3
						$\frac{1}{2}$	20.37	7.40	55.8	37.7
						$1\frac{1}{2}$	20.31	7.50	49.0	36.2
						$2\frac{1}{2}$	20.33	7.50	45.5	34.0
						$6\frac{1}{2}$	24.63	7.42	40.7	36.8
3	L6	11.4	.....	5.7 c.c. avertin fluid in 190 c.c. water (500 mg. per kg.)	.....	Control	18.62			
						$\frac{1}{2}$	17.02			
4	B3	16.0	500 c.c. $3\frac{1}{2}$ hrs. before avertin	8.0 c.c. avertin fluid in 270 c.c. water (500 mg. per kg.)	Cyanotic. Resp. depression. Arti- ficial resp.	Control	20.80	7.50	49.1	38.4
						$\frac{1}{2}$	17.98	7.39	50.6	37.3
						$1\frac{1}{4}$	21.76	7.47	47.4	37.4
						$2\frac{1}{4}$	21.30	7.50	47.6	38.2
5	B4	24.9	830 c.c. 35 min. before avertin	12.45 c.c. avertin fluid in 415 c.c. water (500 mg. per kg.)	Resp. depression. Art. resp. for 15 minutes	Control	.....	7.62	56.1	39.2
						$\frac{1}{2}$	.....	7.39	53.0	37.5
						1	.....	7.53	52.3	36.2
6	B5	13.9	450 c.c. 45 min. before avertin	6.95 c.c. avertin fluid in 225 c.c. water (500 mg. per kg.)	.....	Control	19.55	7.48	45.7	40.4
						$\frac{3}{4}$	16.79	7.50	48.5	38.2
						2	19.13	7.54	41.5	40.0
7	B6	26.3	.....	11 gm. avertin crystals and 2.15 c.c. avertin fluid in 440 c.c. water (500 mg. per kg.)	.....	Control	23.95	7.50	49.9	
						$\frac{1}{2}$	20.67	7.40	48.3	
						1	21.22	7.50	46.5	
						2	22.25	7.52	45.9	
8	B7	23.9	.....	9.5 c.c. avertin fluid in 320 c.c. water (400 mg. per kg.)	R e s p. cessation with extreme cy- anosis. Air intra- tracheally for 25 m.	Control	22.0	7.52	57.6	
						$\frac{1}{2}$	22.47	7.45	56.7	
						1	23.45	....	51.1	
9	B8	31.8	.....	12.72 c.c. avertin fluid in 420 c.c. water (400 mg. per kg.)	Some cyanosis but no resp. cessa- tion	Control	.....	7.50	52.2	39.9
						$\frac{1}{2}$	.....	7.50	57.6	39.2
						1	.....	7.50	50.9	38.8
10	B9	26.0	.....	10.4 c.c. avertin fluid in 350 c.c. water (400 mg. per kg.)	Pure oxygen intra- tracheally. Good color throughout. No artificial resp.	Control	22.76	7.41	52.9	38.0
						$\frac{1}{2}$	20.77	7.32	53.2	36.7
						1	20.57	7.52	51.1	36.2

or two hours following its administration has not been noted with amytal.

#### BODY TEMPERATURE

Table iv includes 7 observations, although more were made. In every case, there is a definite fall in body temperature from 2° to 5°C. which is probably due to the general quiescence of the animal and the decreased body metabolism. It is interesting to note in this regard that Harnack and Meyer<sup>10</sup> have shown that amylene hydrate (the solvent for avertin in avertin fluid) produces a definite fall in body temperature, but unfortunately we were unable to make a comparative study of the body temperature following the administration of crystalline avertin and avertin fluid, inasmuch as we were unable to obtain the former when the problem presented itself.

#### SUMMARY

Avertin has very little action upon liver function as determined by the bromo-sulphalein test, comparing favorably in this respect with amytal and ether. It produces marked kidney depression in the dog for one or two hours, but much less so in man, probably because of the smaller dose employed. When there is little or no respiratory depression and a good color is maintained, the blood bicarbonate content is little affected. With definite respiratory depression, the blood bicarbonate increases, due, presumably, to the attraction of bases into the blood. The increase in the hydrogen-ion concentration of the blood is probably due to two factors, anoxemia and disturbed phosphoric-lactic acid metabolism. Hydremia, followed by a slight degree of blood concentration and a definite fall in body temperature, also occurs.

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# ANGINA PECTORIS\*

## PARAVERTEBRAL ALCOHOL BLOCK FOR THE RELIEF OF PAIN

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SINCE the original suggestion of cervical sympathetomy by Francois Franck and the first actual surgical interference for the relief of angina pectoris by Jonesco of Bucharest in 1916, surgeons have attempted to relieve the agonizing pain incident to cardiovascular disturbance. That the surgical attempts are based on insufficient and inadequate anatomical, physiological and pathological evidence is amply borne out by the great variety of surgical procedures attempted.

### ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

Before reporting our procedure, a brief description of the cardioaortic afferent nervous system will be discussed. The method used is based upon the following anatomical and physiological facts. The cardiac plexus is brought into contact with the sympathetic system through three cardiac nerves, i.e., the superior, middle and inferior cervical cardiac nerves. These nerves originate from the superior, middle and inferior cervical ganglia. The right superior cervical cardiac nerve enters the deep cardiac plexus and gives a few branches to the anterior surface of the aorta. The left superior cervical cardiac nerve joins the superficial cardiac plexus. It is of importance to note that the superior cardiac nerve communicates freely with the middle cardiac nerve and with the superior cervical cardiac branch of the vagus. The middle cervical cardiac nerve arises from the middle cervical ganglia. Often this nerve and ganglion are entirely absent. Both the right and left middle cervical cardiac nerves end in the deep cardiac plexus. The middle cervical cardiac nerve inosculates in the neck with the

superior cervical cardiac nerve and the inferior laryngeal nerve of the vagus.

The inferior cervical cardiac nerve arises from the inferior cervical ganglion and at times from the first thoracic ganglion. It inosculates with the middle cervical cardiac nerve and the inferior cardiac nerve. The lowest cardiac nerve terminates in the deep cardiac plexus. The vagus nerve also ends in the deep cardiac plexus. The nerves of the heart are derived from the cardiac plexus. These nerves pass down along the aorta and are distributed to the auricles. From there they accompany the coronary arteries along the auriculoventricular groove, forming the coronary plexus. From this plexus branches are given off to the ventricles. The ascending aorta has nerve fibers which are in relationship through the rami communicantes with the first six spinal thoracic segments. There is some question as to whether the afferent fibers of the inferior cardiac nerve pass to the fourth, fifth, sixth and seventh cervical nerves. There is some evidence to the contrary. First, clinically, it is rare for pain to appear over the dermatomic segments supplied by the fourth, fifth, sixth and seventh cervical roots. Embryologically there is also some evidence against this occurrence. Head showed that afferent fibers from the heart enter the upper cervical and thoracic segments, extending from the first to the seventh dorsal segments. Apparently in the development the fibers going to the lower cervical nerves are not developed from the inferior cardiac nerves. All three cardiac nerves convey motor impulses to the cardiac plexus. Ranson maintains that most or all of the constrictor fibers to the aorta and coronary vessels come through the superior cardiac nerve. The sensory afferent impulses from

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the middle and inferior cardiac nerves reach the spinal cord through the rami communicantes. They enter into the thoracic segments, extending from the first to the seventh segments. These sensory afferent fibers are finely myelinated. Edgeworth maintains that such fibers pass into the central nervous system by way of the rami communicantes into the upper thoracic segments.

The accompanying diagram (Fig. 1) is a representation of what is generally known and accepted concerning the anatomical and physiological connections of the cardiac nerves to the spinal cord. Hypothetical nerves, such as a special depressor nerve and the vertebral nerve and structures seen in comparative anatomical studies but not established for human beings, have been passed over lightly in this discussion. Since every conceivable combination of operations has been performed and since the beneficial results are far from constant, an explanation of the varying results may be offered. Careful examination of the diagrammatic representation of the nervous mechanism shows quite conclusively that not only are the cervical ganglia in union with one another, but also that the cardiac nerves inosculate with each other as well as with fibers of the vagus. It is quite evident that the removal of any combination of ganglia and cardiac nerves leaves other pathways for pain stimuli to proceed to the brain stem and cord. Even if one were bold enough to attempt in a human the extirpation of all of the cardiac nerves on both sides, together with both vagi (if it were possible), impulses from the cardiac plexus and aorta would still pass into the spinal cord by means of the rami communicantes through the aortic nerve. They would enter into the cord from the first to the seventh dorsal segments.

Since most of the experimental work has been done on lower animals and since the operations on man have shown no definite, constant, results, the following

question arises: What are the pathways for cardiac pain? At present the answer is not known. We do know, however, that irrespective of the place of origin of painful stimuli and irrespective of the cardiac nerves through which they pass, they must ultimately pass into the spinal cord or brain stem to travel by way of the spinothalamic tracts to the thalamus and ultimately reach the sphere of consciousness.

The problem can be solved by ascertaining definitely this point of entrance of the pain conveying fibers. With this knowledge, a mechanical interruption of the continuity of these entering fibers would prevent the pain stimuli from entering the cord. Head and MacKenzie suggested that painful stimuli passed from the heart by means of sympathetic fibers to dorsal root ganglia. The pain was thus referred to the surface dermatomes supplied by the irritated dorsal root ganglia. Any method, therefore, that would indicate through which dorsal root ganglia the mass of pain stimuli are passing, would indicate the exact areas to apply surgical intervention in order to block this entrance of pain impulses into the spinal cord. Another neurophysiological conception is important. Cells in the dorsal root ganglia that are being bombarded are hyperirritable to external stimuli. If a dermatome supplied by an irritable dorsal root ganglion is scratched with a pin or irritated by heat, it will produce a greater sensory reaction than would a skin area supplied by a normal dorsal root ganglion. Based on the foregoing premises, careful protopathic and epicritic sensory tests are made so as to determine the dorsal root ganglia that are being bombarded by pain stimuli. The object, therefore, is to destroy the poorly myelinated afferent sensory fibers from the heart which are passing through the sympathetic cords to enter a dorsal root ganglia. This can be done by destroying either the dorsal root ganglia or the afferent sensory, poorly myelinated fibers running in the sympathetic cords.



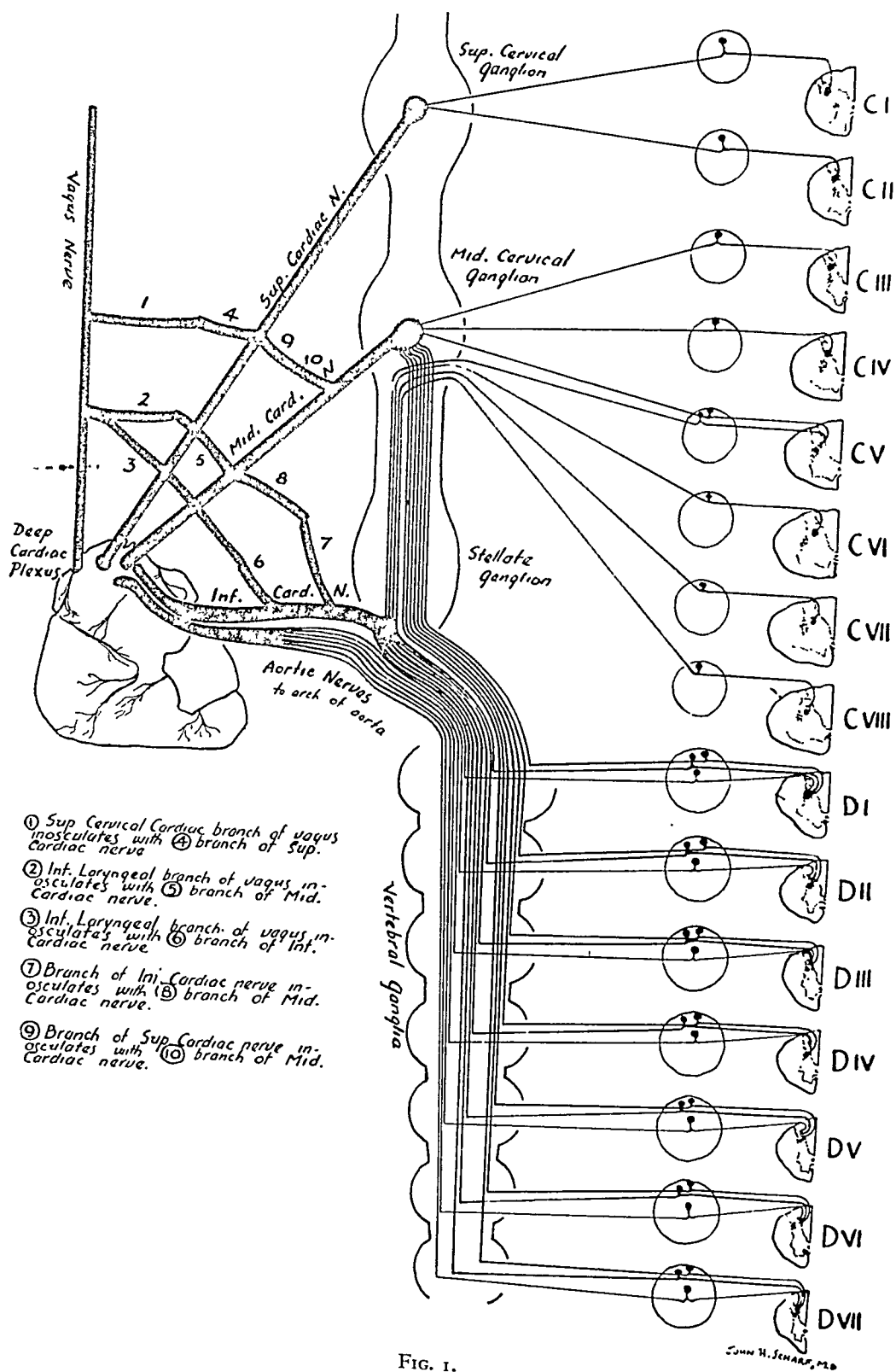


FIG. 1.

JOHN H. SCHARF, M.D.

#### EFFECT OF ALCOHOL INJECTED INTO NERVE TISSUE

Dogiel in his researches showed that the afferent sensory sympathetic fibers are finely myelinated. It is also known that these lightly myelinated afferent sensory sympathetic fibers arborize about certain cells in the dorsal root ganglia, i.e., Dogiel cells.

With the injection of alcohol into the dorsal root ganglia or into the sympathetic fibers in the vicinity of the dorsal root ganglia an intense Wallerian degeneration ensues.

In our cases we have used 3 to 5 c.c. of an 80 per cent to 85 per cent solution of alcohol paravertebrally in order to produce such destruction.

#### CLINICAL EVIDENCE CONCERNING THE PATH- WAY OF CARDIAC PAIN AS ASCERTAINED BY THE SUBJECTIVE RADIATION

Irrespective of the place of origin of the painful stimuli which give rise to cardiac pain and of the nerves through which they pass, these impulses must ultimately pass into the spinal cord or brain stem to travel by way of the spinothalamic tracts in the spinal cord to the thalamus and thus ultimately reach the sphere of consciousness. Before entering the spinal cord, however, these pain impulses, as with any pain impulses, must first enter the dorsal root ganglia, so as to give rise to the phenomenon of referred pain. It is upon these basic physiologic principles that these subjective pain areas, as complained of by the patients, are explained. Of further interest are the observations, that the areas complained of are parts of the body surface relegated in nearly all of the cases to dermatomic segments that are supplied by those spinal nerves found between the eighth cervical and seventh thoracic segments. In a careful examination of the histories personally taken, as well as a perusal of the literature of many cases of pain due to angina pectoris, coronary disease and aortalgia, one is quite forcibly

struck with the fact that the radiation of pain is relegated quite consistently to those areas of the body supplied by the eighth cervical down to the sixth or seventh dorsal (C VIII to D VII) nerves. These observations also revealed that any part or all of the chest may be subjectively referred to as the seat of the pain. Although it is true that at times the patients complain of pain in the back of the head (C I and II) or in the ear (C II) and at times in the lower jaw (trigeminal), yet it is worthy to note, that these two former sites are of rare occurrence while the last site is indeed a curiosity. A complaint of pain along the outside of the arm, which is supplied by the fourth, fifth, sixth and seventh cervical nerves is of such rare occurrence, that its actual existence is greatly to be doubted. In fact, anatomically, it is quite likely that no afferent sensory fibers of the inferior cardiac never pass through these four latter cervical nerves. Embryological studies also seem to support this conclusion. Therefore, from a clinical point of view as ascertained by the subjective complaints of the patients, we can logically say that the impulses which produced pain passed through dorsal root ganglia which supplied those dermatomic segments innervated by nerves emerging from between the eighth cervical and seventh dorsal spinal segments.

#### CLINICAL EVIDENCE CONCERNING THE PATH- WAY OF CARDIAC PAIN AS ASCERTAINED BY THE NEUROLOGIC EXAMINATION (HEAD ZONES)

As stated, all sensory impulses which are conveyed by nerve fibers from an organ, must first enter into dorsal root ganglia before entering the spinal cord to be conveyed by the spinothalamic tracts to the sensorium. The spinothalamic fibers transmitting these stimuli arborize about cells in the dorsal root ganglia known as Dogiel cells. The constant bombardment of these somae by discharges coming from a diseased organ produce in these cells a state of hyperirritability. When a sensitive

dermatome, which is supplied by such an irritable cell, is roused by any physical agent, that is pin prick, heat, cold, painful

Head zones over the back of the head (C I, II) or over the lower jaw (trigeminal nerve). The investigation also failed to

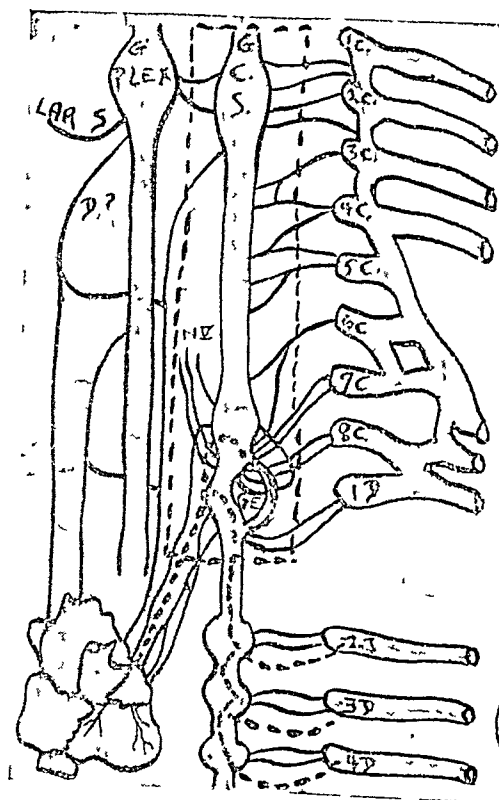


FIG. 2.

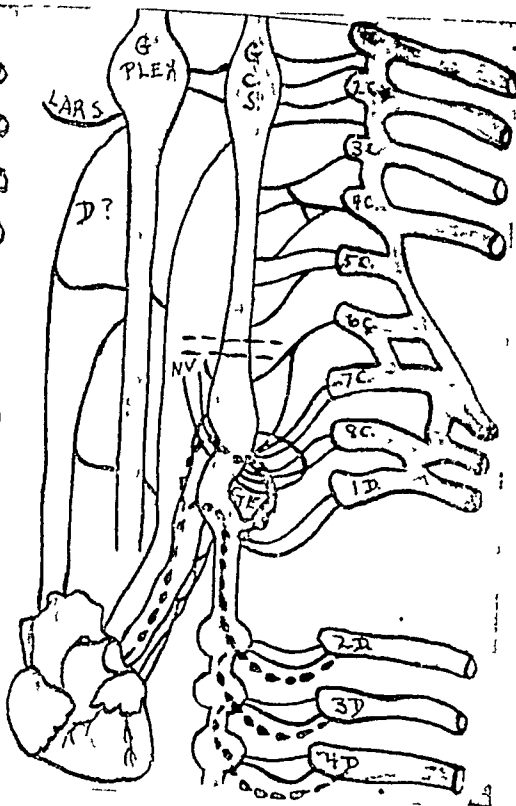


FIG. 3.

response ensues. We thus see that this method of investigation is of great value in ferreting out those ganglia which are the recipients of the continuous stream of painful impulses from the diseased organ. Simply stated, this method reveals the pathway along which the painful influences are traversing so as to enter the spinal cord. Based upon these neurophysiologic facts, careful epicritic and protopathic tests were performed. In the 22 cases observed by the writer, definite sensory changes were observed over the skin. In all cases the protopathic skin tests clearly gave proof of the hypersensitiveness of the skin. Those zones of hyperirritability were limited to areas of the skin supplied by those peripheral nerves which emerge from between the eighth cervical down to the seventh thoracic spinal segments. Again, it is of value to note that the neurological examination failed to elicit

reveal any hypersensitiveness of the skin to these tests over the radial aspect of the upper extremities (C IV-VII).

This method, therefore, also seems logically to suggest that the discharges of pain from the heart pass via those sympathetic fibers and dorsal root ganglia that are emerging between the eighth cervical and seventh dorsal (C VIII to D VII) spinal segments.

#### OPERATIVE EVIDENCES AS TO THE PATHWAY OF CARDIAC PAIN AS ASCERTAINED FROM THE VARIOUS PROCEDURES

In the review of the various operative measures instituted for the amelioration of the severe pain incident to cardiac disease, data were also elicited which clearly indicated what was not the pathway of pain from the heart. Nevertheless, these failures in the several surgical attempts to relieve the pain are of invaluable impor-

tance in indicating the correct pathways. The various surgical operations will be reviewed and discussed briefly, so that a

These operators sectioned the cervical sympathetic cord on the left side above the stellate ganglion (Fig. 3). Along with

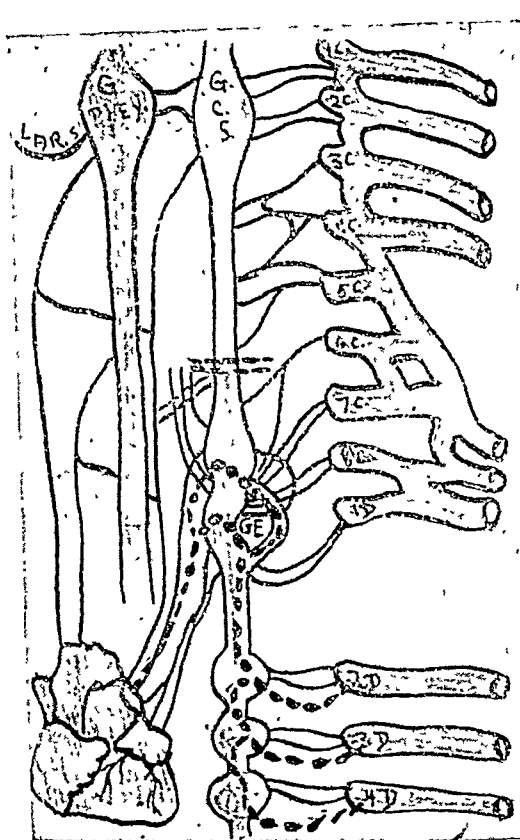


FIG. 4.

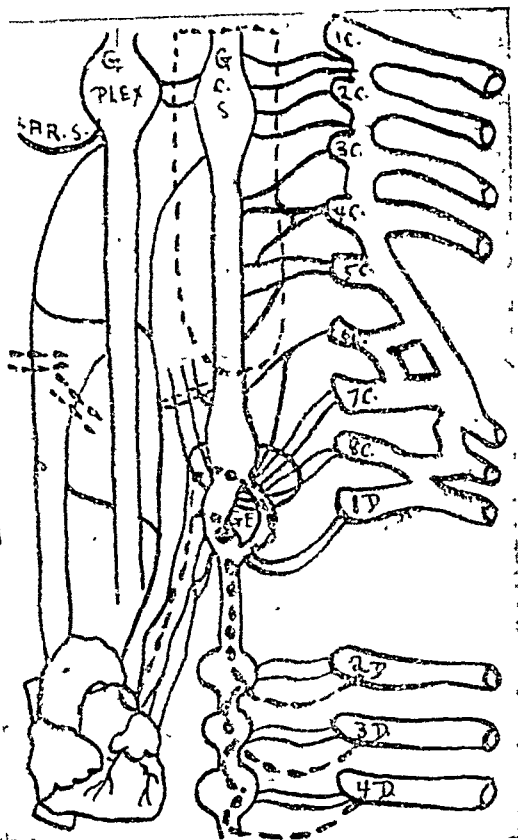


FIG. 5.

clearer understanding may be obtained as to the significance of the information elicited, thus aiding in the disclosure of the correct pathway for cardiac pain.

1. *Method of Jonesco.* By this method the entire cervical chain, along with the first thoracic ganglion, was extirpated (Fig. 2). Danielopolu objected to this method. He contended that this operation severed the vasomotor fibers to the coronary arteries as well as the vasoconstrictor fibers to the lung. These objections were answered by Jonesco in a recent article. He asserted that physiologists, supported by extensive experimentation, are of the opinion that the sympathetics are vasoconstrictors. Hence the removal of the sympathetics does not impair the efficiency of the coronaries but, in fact, augments it.

2. *Method of Danielopolu and Hristide.*

this section, the spinal ganglia of the spinal nerves on the left side were injected with alcohol. At that time the operators were not ready as yet to report the value of this method.

3. *Method of Danielopolu.* (A) On January 1, 1924, this surgeon reported that Gino Pieri of Bellino was the first to follow the operator's new method. He sectioned the cervical sympathetic chain above the stellate ganglion, together with the vertebral nerve, as well as a nerve which joins the superior cervical ganglion to the cranial nerves (Fig. 4). The immediate results were good. No reports as to the condition of the patient at a later date were given.

(B) In October, 1924, Danielopolu reported resection of the sympathetic cervical chain without removal of the inferior cervical ganglion and the first thoracic ganglion

(Fig. 5). In addition he sectioned the vertebral nerve and the branches of the vagus, which were about to enter the thorax.

thetics, together with the superior cardiac nerve on the left side. Hoffer in 4 cases of angina pectoris dissected the vagus nerve

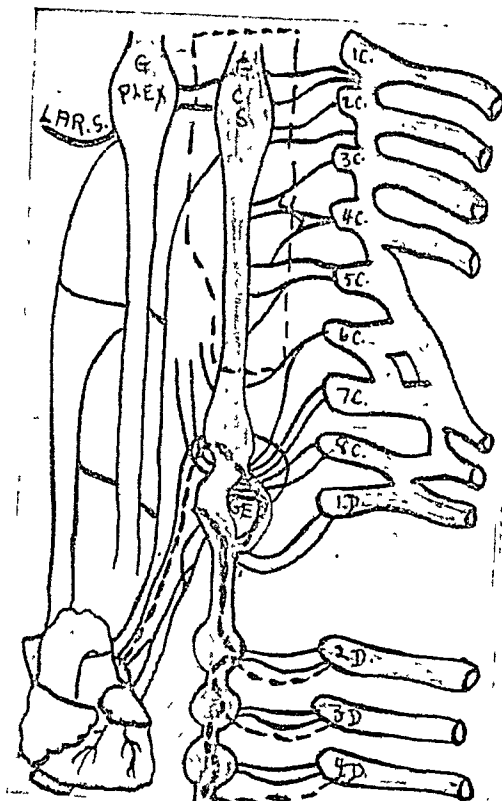


FIG. 6.

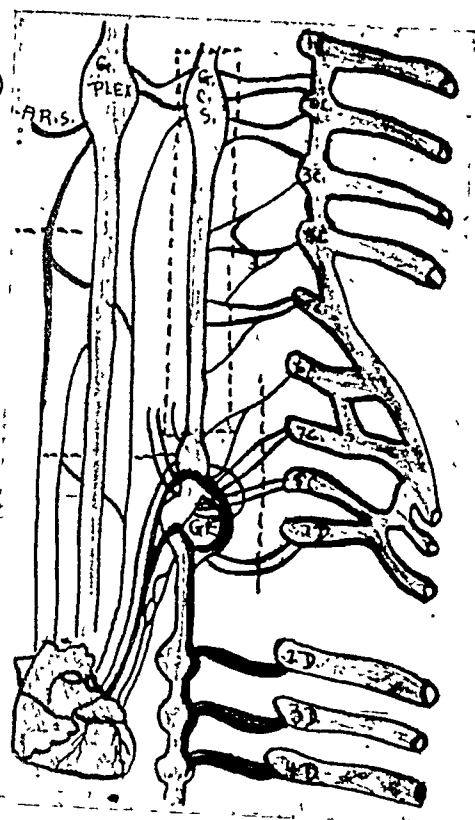


FIG. 7.

(c) In a less complete operation the superior and middle cervical ganglia were extirpated on one or both sides (Fig. 6). In January, 1925, Lilienthal reported 3 such cases with good results.

(d) In February, 1925, the following operation was performed by Danielopolu: the cervical sympathetic chain was resected. The inferior cervical ganglia, as well as the first thoracic ganglia, were left intact. The vertebral nerve was sectioned. All branches leaving the vagus to enter the thorax were severed. The rami communicantes, which joined the inferior cervical ganglion and the first thoracic ganglion to the last pair of cervical nerves, were severed (Fig. 7). In addition to these operations, Eppinger and Hoffer sectioned the so-called depressor nerve, while Coffey and Brown severed the cervical sympa-

without influencing the severity of the pain.

The resume of these various operations shows quite suggestively that if pain impulses do pass through the middle, superior cervical ganglia and vagus they do so in a very minor degree. These observations are quite supported by the animal experimentations to be later discussed as well as by the results obtained by the paravertebral alcohol nerve block.

#### EVIDENCE AS TO THE PATHWAY OF CARDIAC PAIN ELICITED BY MEANS OF THE PARAVERTEBRAL BLOCK

This evidence is based upon 22 cases of my own together with 5 cases reported from the Massachusetts General Hospital and 16 cases of Mandl's.

In a recent paper from the Massachusetts General Hospital 5 additional cases

were reported in great detail in which the alcohol paravertebral alcohol block was used with admirable results. Mandl also reported 16 cases treated by this method with excellent results. This discussion, therefore, is based on a total of 43 cases, treated independently by three different operators. This method is of invaluable aid in the study of the route taken by these impulses which incite the perception of cardiac pain, in that we destroy nerve fibers and then observe what happens to the complaint of pain as personally expressed by those treated. The following theoretical principles are of value in understanding the paravertebral alcohol block as a method in studying the course of cardiac pain. As previously stated, the cardiac pain was referred subjectively to the surface of the body supplied by part or all of the nerves coming forth from between the eighth cervical down to the seventh thoracic nerves (C VIII to D VII, and again, as formerly set forth, these very same skin segments were the ones which were sensitive to skin tests. The conclusion was quite evident, that if these irritable ganglia or sympathetic fibers which came to the ganglia from the heart loaded with pain impulses, were destroyed, and if pain, as a result of the destruction, disappeared, the pathway of cardiac pain to a great extent would be solved. In light of the fact that an 80 per cent solution of alcohol destroys myelin and since the afferent sympathetic fibers are finely myelinated, a paravertebral alcohol block was performed, injecting each of the irritated ganglia. In all of the cases, the paravertebral injections were confined to those ganglia found between the eighth cervical and seventh thoracic (C VIII to D VII) spinal segments. The analysis of the 43 cases showed that those treated were mostly far advanced patients of heart disease, who suffered because of the persistent agonizing pain, that they all received a paravertebral alcohol injection into some or all of the dorsal root ganglia and rami communicantes which extended between the eighth cervical

and seventh dorsal (C VIII to D VII) spinal segments, that, except for 5 cases, they were all relieved, in various degrees.

The results can be briefly summarized as follows:

1. Twenty-two patients suffering from attack of severe precordial pain, were treated by paravertebral injections of alcohol. Satisfactory relief was secured in every instance, except 2, i.e., 11 cases gave from 90 to 100 per cent relief, 7 cases gave from 50 to 85 per cent relief, and 4 cases were relieved from less than 50 per cent to nothing.

2. The alleviation of the pain following a single injection has usually lasted several months. One patient, who was reinjected after several months of relief, has again been made comfortable for a period of several months. This freedom from pain is still enjoyed.

Since the cardiac pain was relieved by the destruction by alcohol of the irritated ganglia found between the eighth cervical and seventh thoracic, we can reasonably say that the impulses of pain were intercepted by the alcoholic destruction of the nerves before they were able to enter the spinal cord, and since only nerves found between the eighth cervical and seventh thoracic were so destroyed, the conclusion naturally follows, that the pathway of pain is through those rami communicantes and dorsal-root ganglia found between the eighth and seventh dorsal (C VIII to D VII) spinal segments.

#### COMPLICATIONS AFTER INJECTIONS

In my own series of cases 5 of the patients complained of severe pain along the nerves injected. This persisted over a period extending from one to forty days. In some, the pain was sharp and paroxysmal while in others it was characterized as a dull ache. In all, however, the pain finally disappeared. There is no question in my mind that the pain is due to the chemical irritation of the alcohol inciting an alcoholic neuritis. This is borne out by

the evidence elicited by sensory tests over the skin.

In 1 case there developed a pneumothorax. I am unable to explain this. The suggestion that the needle accidentally punctured the pleura and thus produced this complication does not seem convincing in light of the fact that there was no resulting pleurisy with effusion. It is almost inconceivable that alcohol could be introduced into the pleural cavity and no pleurisy with effusion result.

There were no deaths occurring on the operating table or immediately thereafter in spite of the fact that desperate cases were particularly chosen for treatment.

#### EVIDENCE ELICITED BY MEANS OF ANIMAL EXPERIMENTATION AS TO THE PATHWAY FOR CARDIAC PAIN

In a recent paper by D. Jonescu, experimental observations were made upon dogs and cats as to the course taken by discharges capable of producing cardiac pain. His experiments support the same conclusions as were arrived at through our clinical studies upon human beings. The following is a resume of the method used by the experimenter and the interpretation of the results as made by him. The experiment may be divided into four steps.

Step 1. Upon the pericardium or epicardium being pinched or pulled, or on the application of a 10 per cent solution of ammonium or barium chloride to the left ventricle or on making a similar chemical application to the adventitia of the left coronary artery or aorta, definite manifestations of pain reactions upon the part of the animals were seen, that is, marked movements of defence, increased respirations, rise in the blood pressure.

Step 2. The next step of the experiment was to sever on the left side the rami communicantes of the eighth cervical and the first thoracic (C VIII to D I) as well as the rami communicantes of the thoracic sympathetic chain down to the sixth ganglion. The first thoracic ganglion was not removed so as to permit its continuity

with the cervical sympathetic chain and the vertebral nerve. With this section accomplished, there remained the following routes for the transmission of pain impulses from the left heart, the vagus with its depressor branch, the superior cardiac nerve, the cervical part of the sympathetic ganglionated chain, the vertebral nerve. Again the epicardium and pericardium, the left coronary artery and aorta were stimulated as was done in Step 1 and none of the reactions of pain as already described appeared in the animal. However, when the right ventricle was stimulated, a display of pain reactions was again elicited, though mild in nature. No evidences of pain resulted at all when the aorta was stimulated, even though the nerve structures were preserved on the right side.

Step 3. The next step was to resect on the right side the rami communicantes, which extended from the eighth cervical down to the sixth thoracic (C VIII to D VI). The application of the physical and chemical stimuli to the left or right ventricle, coronary artery or aorta roused no pain manifestations. This absence of pain is observed even though the vagus nerve, the depressor nerve, the superior cardiac nerve, the vertebral nerve and the cervical sympathetic chain are left unmolested.

Step 4. In other experiments as carried out in man, the same operator stimulated the cranial end of the sympathetic chain but no pain was produced.

Additional evidence was brought by Schittenhelm and Kappis to the effect, that the cervical sympathetic chain does not transport pain discharges from the heart and the aorta. They observed an attack of angina pectoris during an operation. They immediately injected novocaine into the trunk of the cervical sympathetic chain with no relief ensuing, while upon injecting the stellate ganglion, there was at once a suppression of the pain. In an earlier paper, D. Jonescu showed that the electrical stimulation of the cranial end of the vagus nerve as well as the depressor nerve or vertebral nerve, when found in

man, incited no pain reactions. Hoffer noticed in 4 cases of angina pectoris no influence upon the pain by severing the vagi. D. Jonesco pinched and pulled upon the vagus nerve without inducing pain evidences in the animals experimented upon. The experiments of Jonesco, together with the work of Hoffer, Schittenhelm and Kappis lead to the conclusion, that the impulses of pain pass from the heart through the stellate ganglion (C VIII and D I) as well as those rami communicantes that are found between the eighth cervical and sixth thoracic spinal segments.

#### SUMMARY

This paper is presented to correlate our previously observed clinical findings in patients complaining of severe cardiac pain with the information obtained by others through animal experimentation. The clinical observations showed, that subjectively, the pain was relegated to areas of the skin which were supplied by nerves arising between the eighth cervical and seventh thoracic spinal segments (C VIII to D VII). These very same skin areas to which the patients subjectively referred the pain showed them to be hypersensitive to protopathic tests (Head zones). These findings indicated that the pain impulses were passing through the rami communicantes and ganglia, which were to be found between the eighth cervical and seventh thoracic spinal segments (C VIII to D VII). The indifferent operative results ensuing from procedures upon the cervical sympathetic chain and other nerves in the neck indicated by their failure to ameliorate the pain, that the painful charges were not passing through these structures in their course to the sensorium. A review was made of 43

patients suffering from severe cardiac pain, who were treated by paravertebral block. The injections were confined to those rami communicantes found between the eighth cervical and seventh (C VIII to D VII) spinal segments. The gratifying results obtained seem to quite directly suggest that these rami communicantes and ganglia are the true conveying pathways of the pain impulses to the spinal cord so as to reach the spinothalamic tracts.

In a group of 22 cardiac patients suffering from attacks of severe precordial pain, who were treated by paravertebral alcohol injections of the dorsal root ganglia, prompt and satisfactory relief from pain was secured in all but 4 cases.

The freedom from pain following a single injection has usually lasted several months. In one patient, who was reinjected after four months of relief, there has been a second period of comfort lasting several months.

One case of pneumothorax followed the injection. Five cases developed an alcoholic neuritis which disappeared from one to forty days.

The resume of the animal experimentation supports the clinical observations. This showed clearly that the impulses were passing up through those rami communicantes and ganglia found between the eighth cervical and sixth thoracic. Such nerves as the depressor nerve and the vertebral nerve, rarely observed in humans, were stimulated in animals and failed to incite painful reactions. A perusal of all the data indicates quite clearly, that the future surgical procedures for the relief of cardiac pain must have their attention relegated to the rami communicantes found between the eighth cervical and seventh thoracic spinal segments (C VIII to D VII).

[For discussion see p. 105.]





# ANGINA PECTORIS

## TREATMENT BY PARAVERTEBRAL ALCOHOL INJECTION OR OPERATION BASED ON THE NEWER CONCEPTS OF CARDIAC INNERVATION\*

JAMES C. WHITE, M.D.

BOSTON

### I. SURGICAL ANATOMY OF THE CARDIAC NERVES

WHEN Swetlow<sup>1</sup> started to relieve the pain of angina pectoris by the paravertebral injection of alcohol, much of our present knowledge of cardiac innervation had not been worked out. The anatomy of the cardiac nerves is extremely important; first, because it shows us why cervical sympathectomy is so often a failure; second, because it holds out a distinct promise that with the perfection of our methods in attacking the upper dorsal sympathetic fibers, we shall be able to control all types of cardioaortic pain.

The fundamental anatomical facts about the sensory-motor nerve supply of the heart are as follows. Sympathetic afferent and efferent impulses enter and leave the spinal cord over the white communicant rami of the upper fifth to sixth dorsal segments (Fig. 1.) Below this level impulses go to the splanchnic system; above, in the neck, there are no white rami and therefore no connections between the sympathetic trunk and the central nervous system. The white rami leave the dorsal nerves just as the latter emerge from their intervertebral foramina. They then run a short distance below the pleura to the chain of sympathetic ganglia which lie on the anterolateral surface of the vertebrae. It is in this region that the cardiac impulses can be most effectively interrupted by alcohol block or surgical section, because the entire nerve supply to the heart lies concentrated here in the upper five to six pairs of white rami and the corresponding chain of dorsal sympathetic ganglia.

From this point on the pathways become infinitely diverse and complex. One part

ascends to the stellate ganglion and the cervical trunk, to be relayed back to the heart over the superior, middle and inferior cardiac nerves. Between these fibers and the vagus there are numerous anastomoses. A second and very important group of postganglionic fibers leaves the upper dorsal sympathetic trunk, chiefly from the second, third, and fourth ganglia and run directly across the posterior mediastinum to the heart. The existence of these nerves has recently been proved in 2 ways: anatomically by Braeucker<sup>2</sup> and by Jonesco and Enarchesco,<sup>3</sup> who dissected them out; physiologically by Cannon, Lewis and Britton,<sup>4</sup> Brow and his co-workers,<sup>5</sup> and Spiegel.<sup>6</sup> Spiegel's experiments are of vital importance to us. He has demonstrated that dogs, in whom both cervical sympathetic trunks including the stellate ganglia had been removed, gave signs of pain when barium chloride was applied to the heart or when the ascending aorta was stretched. All signs of pain sensation disappeared after he removed the upper dorsal sympathetic ganglia.

The vagus nerve fortunately seems to carry no pain fibers, as there are numerous reported instances where it has been cut or directly injected with procaine without any result during an attack of angina occurring in the course of a cervical sympathectomy.

The direct pathways across the upper thorax were unknown when Jonesco devised his operation of removing the stellate ganglion and the cervical sympathetic trunk for angina pectoris. Today they are being constantly disregarded by surgeons who continue to use the cervical approach. I have gone into these anatomical details

\* Read before the American Society of Regional Anesthesia, Stated Meeting, February 4, 1930.

in order to show that the logical point at which to block cardiac pain is the upper dorsal sympathetic trunk or its upper five

safe procedure, we enlarged its indications to include all severe cases of patients who desired it, after they had had the pros and

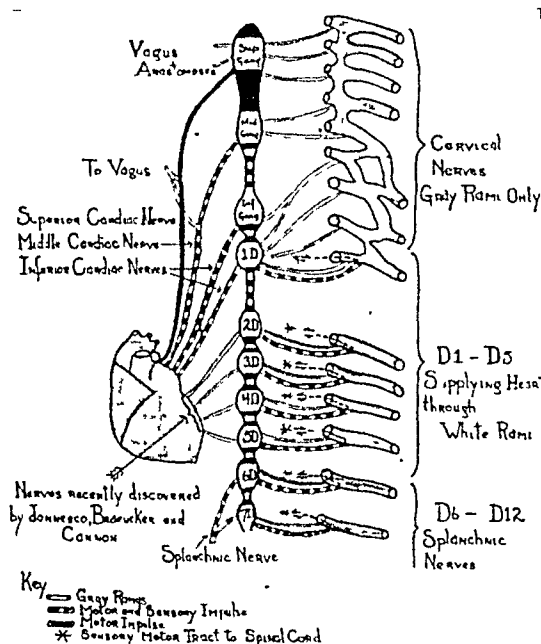


FIG. 1. Connection between central nervous system with cervicodorsal sympathetic trunk and nerves running from trunk to heart. Nerves described by Braeucker, Jonesco, Enarchesco and Cannon, connecting upper dorsal ganglia directly with heart, are sketched in outline.

or six rami communicantes. This is the neck of the bottle; all the sensory fibers entering the spinal cord from the heart are here nicely grouped and vulnerable to alcohol block or direct surgical removal. I have used both methods and can give the results in 21 cases which have been carefully followed over periods varying from three months up to three years.

## II. CLINICAL CASES

1. *Indications and Contraindications:* All the patients in this series have first been submitted to a careful physical examination and thorough course of medical treatment by Dr. P. D. White. Only the ones who did not improve were later injected or operated on by Dr. W. J. Mixer or myself. At first we intervened only in cases where attacks were so severe that life was utterly unbearable. Then, as we found that blocking the cardiac nerves was a really

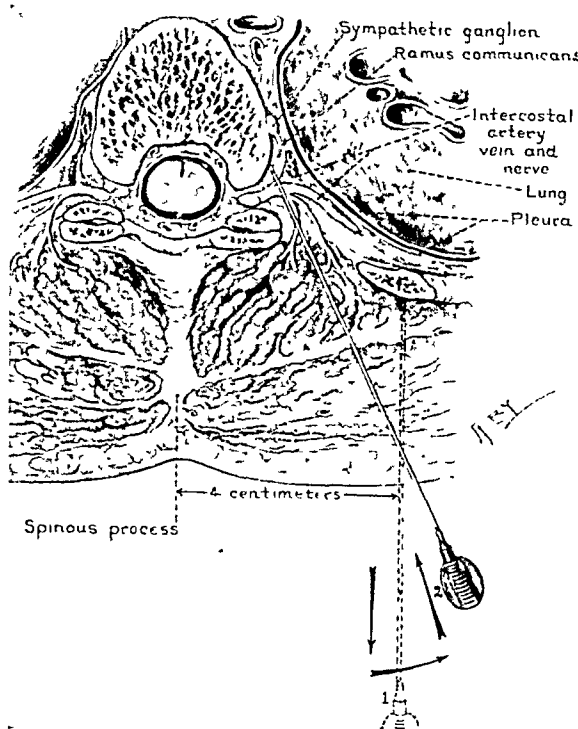


FIG. 2. Paravertebral dorsal block. Needle 1, after taking contact with inferior border of rib, is changed to position 2 and then advanced about 3 cm. further. It should strike body of vertebra close to intervertebral foramen. (From Labat's Textbook of Regional Anesthesia. Saunders.)

cons thoroughly explained to them. For patients who are able to afford complete invalidism and can be constantly cared for, we have been more reluctant to advise it than in poorer patients who are an impossible burden to their families if they are unable to walk about and do a little light work around the house.

There are very few contraindications to alcohol block. I think we should be on our guard against injection in the presence of any active sepsis, as the sterile areas of alcohol necrosis might become infected through the blood stream and set up a serious mediastinitis. Advanced cardiac decompensation would make injection dangerous, but under these circumstances angina is usually absent. Mild decompensation and previous attacks of coronary thrombosis are certainly not a contrain-

dication to injection as they are to operation, for we have injected 9 patients with such a history without bad results.

Danielopolu<sup>7</sup> believes that any interruption of the cardiac accelerator pathways which traverse the stellate ganglion and the inferior cardiac nerves is dangerous, but we have seen no evidence of this. Neither have we found any tendency for patients to overdo in the absence of the danger signal of pain, as claimed by MacKenzie.<sup>8</sup> Shortness of breath, peculiar sensations in the region of the heart without pain, or milder attacks on the right side have always given adequate warning.

2. *Method of Injection:* In the great majority of our cases, numerous anginal attacks have been occurring daily with the patient under observation in the ward. In these instances we have been able to determine accurately which rami carry the painful impulses to the sensorium by preliminary test injections of 5 c.c. of 1 per cent procaine-adrenalin solution, injected paravertebrally into each of the nerves supplying the skin areas of referred pain. These test injections have given pretty constant and complete relief for thirty-six hours; but we have never had results lasting weeks or months such as those reported by Mandl.<sup>9</sup> In the rare patients who cannot be counted upon to have 1 or more daily attacks, we have had to inject alcohol without this very useful information. We have not found Head zones of skin hyperesthesia to be as definite as reported by Swetlow and have not found them particularly useful in deciding which segments to inject.

Our method of injection has been fully described in 3 previous communications.<sup>10</sup> With some recent minor modifications, it consists in first infiltrating 2 c.c. of 2 per cent procaine around the trunks of the upper thoracic nerves as they emerge from the intervertebral foramina and give off their sympathetic rami. We are now using Labat's<sup>11</sup> second technic for inducing paravertebral anesthesia, Fig. 2. The needles are not moved and as soon as intercos-

tal anesthesia develops, proving that they are accurately placed, we slowly inject 5 c.c. of 95 per cent alcohol into each.

3. *Cases Treated by Alcohol Injection:* Table 1 gives a summary of all the injected cases. One patient was injected bilaterally, so there are 19 injections to report in a series of 18 cases. Arteriosclerosis was the cause of cardiac pain in 15, syphilis in 3. The severity of the disease is shown by the fact that out of these 18 patients, 6 had angina at complete rest in bed and 7 had had previous attacks of coronary thrombosis. Most surgeons have felt that the latter condition is a definite contraindication. Of the 18 patients treated, nearly a half (47.4 per cent) have been completely or almost completely freed of their anginal attacks on the injected side and a quarter (26.3 per cent) have been very much improved. Thus three-quarters of the series were definitely successful. Of the remaining quarter, 10.5 per cent were only slightly relieved and 15.8 per cent were failures. Five of these patients have been able to return to work, Case IV as the driver of a heavy truck and Case XI as a mill foreman on his feet ten hours a day. Both were warned that they were overdoing, but felt that circumstances forced them to continue. The former was gradually compelled to lay off by the increasing severity of right-sided attacks, the latter by a cerebral hemorrhage.

There have been no fatalities nor major complications to date, the worst after-effects so far being 1 fairly severe and 2 milder attacks of pleural irritation from the alcohol. These passed off within twenty-four hours. The only troublesome factor has been a pretty constant skin irritation. Beginning usually about a week after injection, the skin anesthesia starts to wear off and is replaced by hyperesthesia. This intercostal neuritis lasts generally from two to six weeks. During this period the patient complains of sharp shooting pains around his chest and soreness of the skin. The hyperesthesia is borne without much complaint by the successful

TABLE I

PATIENTS TREATED BY THE PARAVERTEBRAL INJECTION OF ALCOHOL AT THE MASSACHUSETTS GENERAL HOSPITAL

Case	Age	Diagnosis	Treatment	Results	Degree Relieved, Per Cent	Duration	Status at Last Report
1	54	Syphilitic aortitis, aortic regurgitation hypertension, angina pectoris; confined to bed. Angina decubitus 15 attacks daily	Left D <sub>1</sub> - D <sub>3</sub> 2/19/27 Right D <sub>3</sub> - D <sub>7</sub> 3/20/28	Left-sided relief; development of right-sided pain, no relief	100 (left side) 0 (right side)	3 years	Up and about but unable to work; moderate attacks of right-sided pain
2	60	Hypertensive and arteriosclerotic heart disease, aortic regurgitation, angina pectoris, previous attack of coronary occlusion, slight congestive failure	Left D <sub>2</sub> - D <sub>6</sub> 5/16/27; reinjection D <sub>1</sub> - D <sub>3</sub> 6/28/27	Considerable relief; further relief	60	To death	Able to resume light work until sudden death, undoubtedly from coronary thrombosis or angina pectoris on Feb. 8, 1928; no autopsy
3	53	Arteriosclerotic heart disease, hypertension, angina pectoris at rest	Left D <sub>1</sub> - D <sub>3</sub> 6/9/27	Relief slight but definite; difficult to judge because of extreme nervousness	25	To death 2½ years	Up and about, quietly active, appearing in good health but with moderate angina pectoris. Died of empyema
4	54	Moderate arteriosclerosis and enlarged heart; angina pectoris; incapacitated	Left D <sub>1</sub> - D <sub>3</sub> 7/22/27	Left-sided relief; mild right-sided attacks	100	To date 2½ years	In fair health, but still has right-sided angina pectoris (mild); resumed work as truck driver for three months, but is too short of breath now
5	56	Arteriosclerotic heart disease, hypertension, myocardial insufficiency, previous coronary thrombosis	Left D <sub>1</sub> - D <sub>3</sub> 8/12/27	Relief partial	40	To death 4 mos.	Died suddenly on Jan. 9, 1928, undoubtedly of coronary coronary thrombosis or angina pectoris; no autopsy
6	52	Hypertensive heart disease, aortic regurgitation, angina pectoris at rest	Left D <sub>1</sub> - D <sub>3</sub> 11/5/27	Complete relief at first; later slight recurrence	100	To date 2½ years	Comfortable and able to do light work. 5 mos.
7	58	Arteriosclerotic heart disease, hypertension angina pectoris	Right D <sub>1</sub> - D <sub>3</sub> 3/3/28	Considerable relief	65	To Aug. 1928 5 mos.	Fairly comfortable and has resumed light work
8	68	Arteriosclerotic heart disease, hypertension, angina pectoris, previous coronary thrombosis	Left D <sub>1</sub> - D <sub>3</sub> 4/17/28	Partial relief at first, then recurrence, judgment of case somewhat difficult because of nervousness	50	To death 10 mos.	Uncomfortable, angina pectoris daily but able to be quietly up and about. Died of coronary thrombosis
9	47	Hypertension, arteriosclerosis, coronary thrombosis, angina pectoris; confined to bed	Left D <sub>1</sub> - D <sub>3</sub> 9/4/25	Complete relief of attacks	100	To death 2 mos.	Died of myocardial failure with right-sided angina pectoris on November 4, 1928
10	51	Arteriosclerotic heart disease, coronary thrombosis, angina pectoris, morphinism	Left D <sub>1</sub> - D <sub>3</sub> 9/14/28	Relief of attacks	...	To death 3 weeks	Five days later another attack of coronary thrombosis; died October 4; died too soon to judge
11	56	Hypertensive and arteriosclerotic heart disease. Angina on exertion	Left D <sub>1</sub> - D <sub>3</sub> 6/25/29	Complete relief for 4 months. Slight recurrence 2 months ago	100 90	To date 7 mos.	Worked for 4 mos. Stroke 2 mos. ago. A few slight attacks since
12	57	Hypertensive and arteriosclerotic heart disease. Angina on exertion. Coronary thrombosis	Left D <sub>1</sub> - D <sub>4</sub> 10/6/29	Very much improved	90	To date 4 mos.	Returned to light work. Rare attacks
13	56	Arteriosclerotic heart disease plus coronary thrombosis. Angina on exertion	Left D <sub>1</sub> - D <sub>3</sub> 10/29/29	Complete relief	100	To date 3 mos.	Continues at practice of medicine
14	54	Arteriosclerotic heart disease, coronary thrombosis, decompensation, angina decubitus	Left D <sub>1</sub> - D <sub>4</sub> 10/24/29	Complete relief	100	?	Followed only two weeks
15	49	Arteriosclerotic heart disease, angina on any exertion	Left D <sub>1</sub> - D <sub>3</sub> 10/31/29	Much improved	75	To date 3 mos.	To return to work soon
16	57	Arteriosclerotic heart disease, angina on exertion	Left D <sub>1</sub> - D <sub>4</sub> 11/28/29	No relief	0	.....	Continues as before treatment
17	52	Syphilitic heart disease, aortitis, angina decubitus	Left D <sub>1</sub> - D <sub>4</sub> 11/18/29	No relief	0	.....	Continues as before treatment
18	50	Syphilitic heart disease. Aneurysm of ascending arch of aorta. Pain in upper right chest and neck	Right D <sub>1</sub> - D <sub>2</sub> 2/7/29	Complete relief	100	To death 3 mos.	Died of rupture of aneurysm

cases, although one patient told me that it was as bad as his angina for a week; but in the unsuccessful cases it is really annoying.

I see no way in which this reaction can be prevented, as the sympathetic rami are so short and the ganglia lie so close to the intercostal nerve trunks that there is no way of blocking the one without irritating the other. When 5 c.c. of alcohol are injected into the loose connective tissue between the pleura and the intervertebral foramen, an area of scar tissue about 1 cm. in diameter is produced (observed in the autopsy of Case XVIII and in experimental animals). The alcohol must therefore be deposited with considerable accuracy close to the intervertebral foramen. But unless the injection is made directly in to the nerve trunk itself, the nerve sheath is so impermeable that no more than a transitory peripheral anesthesia is produced. As this wears off, the intercostal nerves are bound to go through a period of hyperirritability; by the end of two months or less, normal function returns. In the case of the delicate sympathetic rami, however, the destructive action of the alcohol usually results in a permanent block. Thus 3 of our patients injected between two and three years ago still report complete relief on the injected side. Only 3 cases have shown any tendency to relapse and in 2 of these the attacks have remained mild in comparison to their former severity. The majority of our successful cases have shown other signs of sympathetic nerve block, e.g. Horner's syndrome, vasodilatation and cessation of perspiration in the arm. In Case XII after four months these changes are still as marked as in patients where we have resected the corresponding ganglia for Raynaud's disease.

Case XVIII is, to my knowledge, the first reported instance of blocking pain in aortic aneurysm. This patient had a huge dilatation of his ascending aorta involving the innominate artery as well. There was constant, severe, aching pain, involving the right upper thorax, neck and posterior

scalp to the top of his head. When he coughed the pain was almost unbearable. The referred pain, therefore, spread over all the spinal segments from the third dorsal to the first cervical on the right side. As the cervical sympathetic trunk is connected with the spine only through the upper dorsal rami, I suspected that paravertebral injection in this region would block the entire area. A test infiltration of procaine into the two upper dorsal spaces on the right blocked the pain for thirty-six hours. Alcohol injected two days later gave complete relief for three months, when the man reentered the hospital because of an acute respiratory infection. He died suddenly of rupture of the aneurysm. Autopsy showed areas of dense scar tissue 1 cm. in diameter at the openings of the 2 upper dorsal intervertebral foramina, surrounding the communicant rami down to the sympathetic ganglia. The parietal pleura was densely adherent to the vertebrae, but the scar did not involve the wall of the aneurysm which was pressed against the spine at this point.

These findings show that alcohol block, when successfully performed, can interrupt the cardiac afferent pathways as effectively as direct operative division. But the cases reported here show that we have injected the alcohol into exactly the right spot in only a half of our cases and fairly accurately in 25 per cent more. Undoubtedly our technic can be improved, but I fear that on account of the depth of the rami and the small area sclerosed by the alcohol, we must always expect a moderate number of unsatisfactory results. However, even in our present state of imperfection, these results are definitely superior to those reported from cervical sympathectomy. The much greater safety of injection over operation is very much in its favor, which means that for the average patient with severe angina and a badly damaged heart, we must strive to perfect our technic and stick to injection. But in the exceptional case of the good surgical risk, we have begun to excise these same nerves by operation.

4. *Operated Cases:* On the basis of our present knowledge of cardiac pain here reported, resection of the upper dorsal sympathetic ganglia seems to be the logical form of surgical approach. I know of no instances in which it has been used in other clinics. In spite of the fact that it is still in its experimental stage and outside the topic of discussion for this meeting, I am including a brief résumé of 3 cases treated by this new operation. I do this because it has increased our knowledge of cardiac pain and because we are planning to use it in preference to injection in the rare anginal patient who we feel can withstand a more radical operative procedure.

Table II summarizes the essential details of these cases. All three appeared to be safe operative risks and were suffering from

TABLE II  
DORSAL GANGLIONECTOMIES IN ANGINA PECTORIS

Case	Age	Diagnosis	Operation	Results
1	18	Rheumatic heart disease. Aortic regurgitation. Up to 18 attacks of angina at rest daily. Severe on left, mild on right.	Resection D <sub>1</sub> — D <sub>2</sub> 2/5/29	Complete relief of left-sided pain. Return to active work. Died at nine months of right-sided attack
2	29	Syphilitic aortitis. Three to four daily severe attacks of left-sided angina.	Resection D <sub>1</sub> — D <sub>3</sub> 9/19/29	Good recovery and no more pain. Died suddenly on eleventh day with severe right-sided pain. Autopsy showed total occlusion of left coronary artery, 50 per cent occlusion of right coronary
3	57	Rheumatic and hypertensive heart disease. Severe angina on left, mild on right.	Resection D <sub>1</sub> — D <sub>3</sub> 10/1/29	Total relief on left. Still has mild right-sided attacks

very frequent severe attacks of angina pectoris. In the cases of two young men, it was particularly important to restore them to some degree of economic independence. Preliminary paravertebral injection of procaine showed that blocking of the stellate and the second dorsal ganglia sufficed to stop the anginal attacks. These patients were operated upon by Dr. W. J. Mixer, Dr. A. W. Allen and myself. We

first removed a small segment of the second rib, subperiosteally as reported by Adson<sup>12</sup> for interrupting the sympathetic innervation of the arm in Raynaud's disease.\* The parietal pleura was then pushed away from the vertebral bodies until the sympathetic trunk came into view. It was then easy to excise the first dorsal portion of the stellate ganglion, the second, and in 2 cases the third dorsal ganglia. This extrapleural approach seemed to cause no shock and all 3 patients made good post-operative recoveries. Case II, on the eleventh day after operation suddenly developed a terrifically severe attack of right-sided precordial pain, from which he died in three hours. Autopsy showed total occlusion of the mouth of his left coronary artery and partial occlusion of the right. This was due to luetic aortitis and was not of recent origin. As there was no other apparent cause of death, it is impossible to say whether his death was a mere coincidence or a direct consequence of operation. If the latter, it is surprising that he should have done so well for ten days.

In all these cases the left-sided angina disappeared completely. It is interesting that all 3 had mild right-sided pain before operation, which was not influenced in any way by the unilateral operation. These right-sided attacks were just severe enough to constitute a good danger signal in Cases I and III. The former neglected his health completely, working hard as an insurance agent and sitting up late nights. After nine months he reentered the hospital with an acute respiratory infection and died suddenly of a severe attack of right-sided angina. Neither in his case nor in the second, was there any trace of pain on the left. The last patient is doing well after four months. She has slight attacks of right-sided pain, which warn her when she is overdoing, but do not prevent her from doing light housework and enjoying mild, social activities.

\*This operation was first proposed by A. K. Henry (*Irish J. of Med. Sc.* 5: 157, 1924), who worked out the procedure on cadavers and suggested its use in angina pectoris.

5. *Discussion:* From my experience with these cases, I have come to the conclusion that paravertebral injection of alcohol is the best treatment that has been developed for the average patient with severe angina pectoris. All of them have reported back to the Cardiac Clinic at frequent intervals and I have taken Dr. P. D. White's opinion of the degree of improvement following injection, in order to be sure of an impartial estimate. A summary of this data classified on a percentage basis, is given in Table III.

TABLE III

	Paravertebral Alcohol Block, Per Cent	Cervical Sympathectomies, Per Cent	
		Total	Partial
Number of injections or operations	19*	66	116
per cent			
Relief { Good { 100 to 90	47 4	58	53
{ 90 to 50	26 3		
{ Improved 50 to 25	10 5	13 4	22
{ Failures 25 to 0	15 8	7 6	13 5
Deaths	0	21	— 5

\* Two cases observed too short a time to be certain of result

This shows that the results of injection are distinctly better than in the large series of cervical sympathectomies collected by Fontaine<sup>13</sup> and Cutler.<sup>14</sup> After removal of the upper cervical sympathetic trunk there is a 7.5 per cent chance of the patient's dying within the first four days; after the complete Jonesco operation, which includes the stellate ganglion, the chances are increased to 21 per cent. So far we have not been sorry that we have injected any patient. Furthermore, the average operated patient requires a hospitalization of nearly two weeks, while for the case treated by injection, three to five days are usually sufficient. In the face of these statistics, no cervical sympathectomy has been performed at the Massachusetts General Hospital during the past three years.

Injection has taught us that when the sympathetic rami of the upper thoracic nerves are successfully blocked, pain in the precordium and inner surface of the

arm disappears on the injected side. This has happened temporarily in every instance following the use of procaine and in every case but one with alcohol, where complete skin anesthesia resulted. When the angina is bilateral, injection on the left has no effect on the attacks on the right. In regard to atypical anginal attacks in the epigastrium and neck, I have not had sufficient experience to make any positive statements. However, in Case xviii, pain referred all over the cervical distribution was relieved when the upper thoracic rami were blocked. Once alcohol has failed, there is little more that can be done for the patient surgically, as attempts at reinjection in our hands have failed and operation would be rendered much too difficult by the scar tissue. It is for this reason that we are beginning to remove these nerves surgically in a few favorable cases where we are willing to take an additional risk in order to be surer of success.

#### SUMMARY

(1) Pain from the heart and ascending arch of the aorta is conveyed to the sympathetic trunk by postganglionic, unmyelinated fibers running in:

a. The superior, middle and inferior cardiac nerves to the corresponding cervical sympathetic ganglia.

b. Recently discovered nerves which run directly across the mediastinum from the posterior cardiac plexus to the upper dorsal sympathetic ganglia.

The painful stimuli are then carried to the spinal cord over preganglionic, myelinated fibers in the upper dorsal white communicant rami. As there are no white rami in the cervical region, all pain sensation referred over the cervical sympathetic trunk must descend to the upper dorsal region before it can reach the spinal cord.

Pain referred to the left, or right precordium and arm, enters the cord only on the same side.

The vagus nerve carries no important sensory fibers.

(2) Operation on the cervical sympa-

thetic trunk, even if it includes the stellate ganglion, cannot interrupt all the pathways of cardiac pain.

(3) The upper dorsal communicant rami or their sympathetic ganglia are the logical points at which to interrupt painful stimuli from the heart.

(4) These anatomical and physiological premises have been put to the test in 21 cases. In each instance where we have been sure of a successful block of the sympathetic rami in the segments of the referred pain, angina pectoris has disappeared.

(5) Alcohol injection is difficult technically, because of the depth of the rami and the small area sclerosed by the alcohol. However, it is the safest method we have

and its results are distinctly better than in cervical sympathectomy. Forty-seven and four-tenths per cent of cases have been over 90 per cent improved, a further 26.3 per cent over 50 per cent, and only 15.8 per cent have been total failures.

(6) A patient with aneurysm of the ascending arch of his aorta was totally relieved of pain referred over the entire cervical and upper dorsal region on the right side by alcohol block of his first and second dorsal rami.

(7) In exceptional patients who are unusually favorable operative risks, we are beginning to remove the upper dorsal sympathetic ganglia, to avoid the 26.3 per cent chance of a poor result following an unsuccessful injection of alcohol.

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#### DISCUSSION OF PAPERS BY DRS. SWETLOW AND WHITE

DR. ERNST P. BOAS: I have had the opportunity of seeing quite a number of the cases which Dr. Swetlow injected, both before and after operation, and I can bear witness to the efficacy of the method in relieving very distressing pain.

I should like to confine myself, if I may, to a brief discussion of certain medical aspects of angina pectoris, and in particular to the indications for this form of treatment. The term

angina pectoris is still used very loosely and many men are apt to consider heart pain and angina pectoris as synonymous. It is not mere academic quibbling to attempt to define this condition a little more exactly. After all, this method of therapy is not altogether innocuous and we should have our indications clearly in mind before we apply it.

From the clinical point of view we may roughly describe four major types of cardiac



pain. The first I should like to call heart pain and nothing else. It is a sharp sticking, stabbing pain, felt most often in the region of the apex, experienced chiefly by people with the so-called irritable heart or neurocirculatory asthenia without any basic organic heart disease. Similar pain is also experienced by patients with mitral stenosis. And finally, a soreness felt chiefly in the region of the apex is not uncommon in certain types of heart failure.

These forms of pain, which we need not discuss any further, are not at all related to angina pectoris; they are often quite unassociated with organic heart disease, and can usually be relieved by general medical measures. In these cases, in spite of the fact that the patients often show cutaneous zones of hyperesthesia, paravertebral injection is never indicated.

The next and most important group of cases are those with true angina pectoris. Their pain is determined by coronary artery disease; their symptoms were fully described by Heberden one hundred and thirty years ago. They experience pain under the sternum, but exhibit no change in pulse or respiration or blood pressure during an attack. The pain is usually induced by exertion or emotional stress, and is often accompanied or followed by zones of cutaneous hyperesthesia. These patients very often can be relieved of their pain by a proper medical regimen, and more particularly by a proper regulation of their life. If their activities are cut down, and they are given instructions which they will intelligently follow, with the aid of certain medication, probably the majority of them find relief.

In this group of patients paravertebral block should be used only when the pain is very frequent, very stubborn, and when all other methods have failed.

For the sake of completeness we should mention as the third group the severe retrosternal pain associated with coronary artery thrombosis, which differs somewhat from the pure angina of the previous group. In these patients, of course, paravertebral block is out of the question during the acute attack, which is usually associated with heart failure. Following the attack they are usually spontaneously relieved of their pain.

The fourth group of cases, possibly the most interesting, we may name "aortalgia," although that assumes a too definite knowledge of the etiology. It is a heart pain very much

like that of true angina pectoris, felt over the upper sternum, induced very much as the pain of angina pectoris. These patients instead of being immobile with slow pulse and undisturbed respiration during the attack, are restless and nervous, are likely to toss in bed, or to walk about. There is a rise in heart rate and in blood pressure and a marked vasomotor reaction. The attacks occur particularly in nervous patients with hypertension, and in young people with rheumatic aortic insufficiency and in patients with syphilitic aortitis.

It has been my experience that these attacks are most difficult to relieve by medical means. A number of the cases that I have seen injected by Dr. Swetlow were of this group, and the method seemed to accomplish something here which could not be accomplished in any other way.

The introduction of the method of alcohol injection for paravertebral blocking has served two very useful functions: First of all, it has brought relief to a certain small group of patients who could get relief in no other way; and, secondly, it has acted as a counterfoil to the enthusiasm of the surgeons.

Dr. Swetlow indicated the many different types of operations that have been used by surgeons for the relief of angina pectoris. I agree in the opinion that all of these operations are unphysiological, that the mortality is very high, and that operation is never indicated. Formerly, before we knew of paravertebral block, in certain desperate cases where everything had been tried and had failed, we finally did resort to surgery because we did not know what else to do. Now we have a much better technic at our disposal, one which involves much less danger to the patients, and is much more certain of success. One reason why sympathectomy often produces such disastrous results is that with this method not only the afferent pathways through the sympathetic but the efferent, that is the accelerator fibers of the heart, are cut. Apparently the loss of this regulating function is not well tolerated by the heart. In the last issue of the *Archives des maladies du coeur*, Danielpolu has a very interesting series of articles, showing experimentally the damage to the dog's heart after the removal of the stellate ganglion.

Paravertebral block is a useful therapeutic measure, but one which should be restricted to cases of true angina pectoris or aortalgia.

It should be employed only in desperate cases, that is, in those with persistent pain in whom all other medical measures have failed.

DR. JOSEPH MUIR: The subjects treated in the papers to which we have just listened are of absorbing interest to me, although I have never taken any active part in either the surgical interruption of the paths of sensation responsible for the pains of angina pectoris or their elimination by means of toxic injections.

For several years past I have followed the work of Jonesco of Bucharest, and more recently of Lilienthal, the speakers of the evening and others whose work has been done in this country. When we consider that the pain of angina pectoris is probably the most exquisite and excruciating known to man, the sum total of relief from torture which these men have been able to afford suffering humanity, mounts very high.

The proposal and practice of alcoholic injection at once appealed to me as offering a means of escape from the dangers and discomforts which are the inevitable accompaniment of a surgical procedure of such magnitude as cervical sympathectomy, but when it later proved to be more or less temporary in its effects my enthusiasm underwent a certain modification. This same objection, of course, holds true of the methods of nerve blocking. As we have seen, any of these procedures can be repeated as occasion demands, but we are still without a permanent method of relief which does not involve the hazards of major surgery. That radium might possibly offer a way out of this dilemma had occurred to me not long after I decided to devote my attention exclusively to radium therapy.

The idea rested more or less dormant in my mind, however, until a personal accident brought the possibilities of radium in this connection very sharply to my attention. I developed a condition in the ethmoidal sinus for the relief of which a radium seed was inserted and permitted to remain permanently. Many months later I noticed a dimming of the sight of my right eye. Alarmed, I sought the advice of an ophthalmologist who, finding nothing, handed me over to an internist who, in turn, wished me upon a neurologist. While I was undergoing the various tests and explorations the light steadily faded before my right eye until it was totally extinguished.

Then at last we found out the cause. The action of the radium and the presence of the

foreign body in the ethmoid, in close proximity to the optic nerve had destroyed its blood supply, so that atrophy of the nerve had taken place, that is, it had died of starvation.

Is it not reasonable to suppose that when we desire to eliminate nerves whose only function is to convey painful sensations, this same agent of destruction could be made to serve a most useful purpose?

The experiments of Mme. Dobrovolskia-Zavadskaia, carried out in the laboratories of the Paris Radium Institute, showed that when tubes of radium emanation were introduced into the muscular tissues of rabbits several concentric zones of tissue change were to be noted about the site of each radioactive center. In the middle was the zone of necrosis regularly noted whenever radium is inserted in tissue without filtration of the beta (caustic) radiation, or when secondary caustic rays are given off from metal filters. Beyond this zone of frank necrosis was another in which the muscle fibers remained alive, but because of prolonged gamma radiation, had undergone a noticeable diminution of their cytoplasm. This she termed the zone of atrophy, and it is evident that with proper filtration of both primary and secondary caustic radiation we may still be able to produce atrophy of muscular elements by sufficient exposure to gamma radiation.

The atrophy of the optic nerve in my own case was not due directly to the gamma radiation but to failure of the blood supply of the nerve. The changes induced in the walls of the blood vessels inhibited their function long enough to starve the nerve out. Subsequent regeneration of the vessels' musculature might take place, but the nerve would never be restored. So through my blind eye I now perceive a great usefulness for radium in the relief of angina pectoris.

DR. HOWARD LILIENTHAL: I was much interested to hear the opinion of Dr. Boas on the value of surgery in angina pectoris and I was particularly pleased at his admission that he does employ surgery when he does not know what else to do; but no surgeon desires to operate if his patient can be cured by medical means. Whether the injection method or a cutting method is employed makes very little difference so far as this question of medicine and surgery goes, because both cutting and injection are surgical procedures. Doctor Swetlow's paper interested me much as a beautiful exposition of the pain conduction

paths and I willingly accept his demonstration as authentic.

It seems to me that we have to deal with 2 factors in the treatment of this distressing condition. First, the elimination of the disease which produces the phenomenon and second, the mere relief of the pain.

I regard the operations upon the sympathetic nervous system as directed against what I may call the spasticity of the cardiovascular system which is one factor, at least, of the disease itself. Relief of pain would be then incidental because the attacks would be replaced by a certain degree of permanent laxness of the vascular walls.

Second, the blocking of pain conduction which is what Dr. Swetlow's work so brilliantly accomplishes.

In purely spastic angina and especially in aortalgia, one would naturally give preference to the operation of cervical sympathectomy, or at least extirpation of the superior ganglion. When, however, there is actual damage to the heart or its vessels, it is difficult to see how an open operation could be of great permanent aid and I would give preference to alcoholic injection which I am convinced may make life again worth living.

The operation of sympathectomy has unfortunately not been taken up with the enthusiasm which I think it deserves. I believe that the cardiologists with their instruments of precision should be or will be able in many cases to determine which procedure is preferable in a given instance. The fact that the disease will not be permanently cured should not militate against sympathectomy. I have heard the objection raised that if the patient does not have pain he will neglect necessary precautions but I know that in some of my cases, unfortunately too few in number, the patient was able to feel when the attack was coming on by sensations though not of pain, and to behave accordingly, stopping his walk or other exercise and resting until he again felt normal.

In such a condition as angina pectoris which is not really a disease but a symptom, we are probably dealing with various pathological states and to argue for or against any one procedure is unscientific unless we know the cause and character of the disease which we hope to combat.

May I say I was very much pleased to hear Dr. White say what he did about the

posterior mediastinotomy which is a favorite operation of mine in approaching these nerves. At the same time I do not see why this operation, although it is done under the eye and is perhaps, therefore, more scientific than the injection, should supersede the latter method. One should reach the spot accurately with the needle and there is little or no danger even if the pleura happens to be punctured. The needle may touch the bone, having traversed the pleura. Posterior mediastinotomy is a local anesthesia operation. I have done it many times for the exposure of the thoracic esophagus. The incision is the same as that for paravertebral thoracoplasty. Resecting the second, third and fourth ribs, you can get lots of room. The posterior part of the pleura is much looser in its connections with the bony structures than the part of the pleura further forward, and it is easily pushed aside.

DR. LABAT (Chairman): We have here 2 types of surgical procedures: (1) an operative *open* procedure, and (2) an operative *closed* procedure. The first open procedure is cervical sympathectomy. This has given, according to what came out this evening, less favorable results than the second open operation, which consists in the severing of the rami communicantes from the first thoracic to, at most, the sixth thoracic.

Inference may be drawn from what we have heard of the closed procedure that injections of alcohol may well replace the operations of sympathectomy and rami section, whether they be performed in the cervical region or in the dorsal region.

But the main point, and I think it is the most important factor, in this whole session was brought out by Dr. Boas who laid great stress on the necessity of differentiating between the pain, and said that alcohol injections should be reserved to those cases where a differential diagnosis pointed absolutely to angina pectoris or aortic pain.

This, I believe, should be our strict observance: the diagnosis should be well made in order that the treatment be well applied.

We are certainly very thankful to the speakers of the evening for the knowledge which they have brought to us of the pathways of pain in angina pectoris.

DR. WHITE (closing): I have very little more to add. The reason that we started operating instead of injecting the milder cases of angina pectoris was that in 2 of these we had had rather

poor results from unsuccessful alcohol injection. We then determined to make absolutely sure of interrupting the important nerve centers in the next suitable case.

I am sure that if you did this operation on the average old patient with myocarditis and severe angina pectoris, you would have a high mortality, probably as high as in the Jonesco operation. Therefore, it is an operation to be considered only in selected cases; in these I believe that it will avoid the 25 per cent chance

of failure that we now have to face with alcohol. But I hope with improvement of the technic of alcohol injection that no operations at all will have to be used. These patients with alcohol injection have stayed in the hospital from three to five days, whereas a patient with any kind of operation is going to have to stay in for a week or two and he is going to suffer a great deal more than the patient treated with alcohol. That is a final point which is worth considering.



## THE INTRAVENOUS USE OF THE BARBITURIC ACID HYPNOTICS IN SURGERY\*

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WITHIN the last few years many new barbituric acid hypnotics have been synthesized and placed on the market. The individual recommendations of the manufacturers has raised the problem of the relative applicability and usefulness of each new preparation in modern medicine and surgery. The responsibility for this analysis must be equally shared by the clinician and the pharmacologist. The clinician has been, in many instances, compelled to rely on the verdict of the manufacturers relative to the characteristics of their product, with a consequent premature trial of a comparatively unknown drug. The pharmacologist, on the other hand, has found it practically impossible to keep pace with the manufacturing chemists in his scientific comparative evaluation, and has been able to give rather meager data upon which the practitioner can judge the relative usefulness and differential value of these drugs.

In order to alleviate this condition and as far as possible to answer questions about the barbiturates based upon experimental evidence as to characteristics, a comparative evaluation of the more common members of the series that are clinically employed was started in this laboratory over a year ago. It was hoped, in commencing this study, that if the results indicated actual differences other than their toxicities, it might be possible to evaluate these differences in terms of selective uses where the type of action desired could be brought about by a specific barbiturate. This result has been to some extent realized, and while the work is not completed to the end that the protocols are ready for publication, it is

possible at this time to give a few indications of the trend of this research in terms of its clinical applicability.

In the first place, the hope that some of the newer barbiturates might give a deeper depression in like proportions of the fatal dose has not been realized in this laboratory. The toxicities of the various compounds have varied markedly, but the production of a comparative grade of surgical anesthesia in laboratory animals has required approximately the same proportion of the fatal dose in all cases. We are aware that some evidences have already been presented tending to show a difference in therapeutic efficiency, but these differences, in our experience at least, in so far as the depth of depression induced is concerned, have seemed to be less than the personal error in judging that depression. We do not mean to infer from this that there is no choice to be made and that one will serve as well as another in all instances. The selection of the proper barbiturate depends specifically on the type and duration of hypnosis that is desired. Small changes in structure result in marked variability in pharmacologic activity.

Before making any specific recommendation, we would like to analyze just what occurs on the intravenous administration of these drugs. The barbiturates are among the worst offenders with respect to the variability of dosage required to produce similar effects in different animals, or in the same animal at different times. There is no average "dose" of any of them that might not be dangerous to some individuals nor is there one that will produce sleep from the estimated dosage, in all cases. The attempt to estimate any

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fixed dosage is fraught with possibilities of considerable risk to the animal. These hypnotics must be given symptomatically, slowly, and with extreme caution, remembering that the maximal depression is reached probably fifteen minutes after the time of injection. Barbiturate deaths, particularly from long acting barbiturates, in just fatal doses, are almost never the immediate result of a maximal concentration of the drug in the laboratory animal. Pulmonary complications resulting from deficient respiration and loss of body temperature are usually the direct cause of death in experimental animals, particularly dogs. This is not so generally the case with the shorter acting barbiturates in which just fatal doses frequently cause death by respiratory depression. This situation should further emphasize the fact that the greatest danger to the patient may not be merely the depth of the immediate depression induced, but may result from complications developing hours later. The longer acting barbiturates are more liable to result in after-complications of this nature.

On the basis of our experience, we conclude that in no case should the attempt be made to carry the depth of depression to the stage of complete surgical anesthesia. In the first place, the amount required to produce complete analgesia is dangerously near the fatal dose. Laboratory animals are not always effectively anesthetized even when fatal doses are given. The barbiturates are not true analgesics and any attempt to employ them as such constitutes a usage that is bound to result in disappointment. Secondly, the anesthetist has no, or at most a variable and small, margin of safety upon which he can depend in case of unlooked for complications. When a drug of this type is injected intravenously, it is beyond reach so far as the anesthetist is concerned. He may hope that the patient has not received too much, but as far as an effective treatment is concerned, in case he has given too much, there is little he can do. Investigations

at present under way in this laboratory give some promise of a possible antidote which may change this rather discouraging outlook.

A comparison that is not dependent upon the dubious differences in therapeutic efficiency, but upon the duration of marked depression, should be made. It would seem wise, unless some other condition made the contrary desirable, when giving a drug depressant that cannot be controlled after administration, to give a drug the effects of which in similar proportions of the fatal dose would pass off relatively quickly. This shortens the danger period in case of a slight overdose or difficulty of elimination, and lessens the possibility of pneumonic infection resulting from loss of temperature and respiratory depression and resulting weakened condition. This factor is of additional importance when one remembers other complications that occasionally develop from the use of an intravenously administered depressant. On recovery from any anesthetic, certain individuals tend to exhibit manifestations of excitement. This is probably dependent upon the fact that, in the partially recovered or half-conscious individual, the higher centers have not yet begun to function and he reacts as a medullary defensive animal. This fact is not altogether dependent upon postoperative pain stimulation. The same thing is frequently observed in unoperated animals in which pain could not possibly be a factor. The duration of this excitement period is dependent upon the length of time over which the depressant maintains the organism at that stage of consciousness. A gaseous anesthetic will display only transitory manifestations of excitement as it is rapidly eliminated. A long acting depressant, on the other hand, will maintain this condition at times for hours, depending on the length of time over which it acts. It has been this latter difficulty that has brought about some of the most serious objections to the use of the barbiturates in surgery. Occasional long periods of post-

operative excitement and mania are exceedingly undesirable. It is obvious that if this objection is overcome in a barbiturate, it must be accomplished through decreasing the length of time over which it acts. By making the period of action sufficiently short, it may be possible to simulate the fleeting excitement stage seen after use of a gaseous anesthetic.

There seem to be two possible approaches in developing a barbiturate of this type. Either the period of action can be shortened by using a barbiturate that can be more easily broken down by the body, or by the use of a more toxic barbiturate which will necessitate a smaller total quantity of drug to produce the desired effect. It is then necessary to destroy or eliminate a smaller quantity of drug before the body functions again become normal. Experience in this laboratory indicates that both possibilities may in part be realized.

The popularity of amytal has probably been largely due to the fact that it possessed over all the other barbiturates, the advantages which have been outlined here as being desirable. It is several times more toxic than barbital or luminal, and yet its advantages have been quickly recognized. Its shorter period of action has rendered it safer and the after-complications of excitement have been fewer. Its chief disadvantage seems to be that it is not short enough in its action for surgical purposes. It must be remembered that we are not speaking of the barbiturates in terms of their use by mouth as general hypnotics. The criteria of their value in that field may be entirely different from that of their use for the purpose of producing preoperative sleep. Long continued mild depression is certainly desired in many instances for which a longer acting barbiturate may possess a distinct advantage. This is not, however, generally true in surgical procedures where the welfare of the patient may be endangered by other factors than the depressant used, and for which purpose it is well to maintain a

wide margin of safety. For such purposes, it is our opinion that a compound with a shorter period of action than that of amytal is of distinct advantage.

Our laboratory findings indicate that two different barbiturates furnish an approach to this type. These are secondary butyl-brom-allyl barbituric acid (pernocton) and ethyl-methyl-butyl barbituric acid. These two drugs are of approximately the same toxicity, with the latter being slightly more toxic. The duration of their action in experimental animals is shorter than with any other of eleven barbiturates we have studied. Postanesthetic excitation was observed in several animals, but was of considerably shorter duration with both drugs than with amytal or with barbital. The lowering of body temperature and slowing of the pulse and respiration were not marked, due to the shorter duration of action. These facts led us to believe that ethyl-methyl-butyl barbituric acid (Abbott) and secondary butyl-brom-allyl barbituric acid (Riedel-de Haen) would have greatest usefulness for intravenous use where the long action of other members of the series frequently resulted in disturbing complications.

Experimentally, ethyl-methyl-butyl barbituric acid is more toxic and has a shorter period of action than pernocton. This should result in a proportionate advantage when used clinically to produce preoperative sleep. These differences, however, are not so marked as those existing between amytal and pernocton; consequently, to demonstrate them in practice would require a large number of cases and careful checking of the postoperative period of depression.

After having established the foregoing criteria upon which the value of any barbiturate could be theoretically predicted, for intravenous usage, it was decided to make a comparison of the activity of these drugs in human cases.

The comparative toxicities were found to be the same as the laboratory results. To just produce sleep in a previously mor-

phinzied individual required 0.6 gm. to 1.4 gm. of amytal, 0.4 gm. to 0.8 gm. of pernocton, and 0.2 gm. to 0.5 gm. of ethyl-methyl-butyl barbiturate. These were all injected as a 10 per cent solution with the exception of the latter which was occasionally given in a 5 per cent solution, the small volume of the 10 per cent solution that was required leading us to believe that a better control of the injection would result from the use of a larger volume of fluid.

We had felt that intravenous anesthesia produced by these drugs would be extremely useful in cases involving operative procedures about the upper air passages, and accordingly chose at first bronchoscopies and similar surgical cases. It was evident very early, however, that in doses that could be safely employed, the lack of depression of the pharyngeal reflexes, and the poor relaxation of the masseter muscles, made it inapplicable in this type of surgery. On the other hand, as a preparation for block anesthesia, and in particular for cases where extreme apprehension on the part of the patient added to the risk of the operative procedure, we have found the short acting barbiturates to be of advantage.

Attempts to use these drugs as a sole anesthetic agent even for minor surgical operations proved unsatisfactory. As was true with laboratory animals, the reaction to pain even with extreme doses was seldom completely abolished. It was necessary in practically all cases to supplement the barbiturate with a volatile anesthetic. A recognition of that fact indicates that they should never be used otherwise than as an adjunct to other forms of anesthesia; accordingly, the symptomatic administration should not be carried materially beyond the first indications of sleep.

The period of depression and sleep following the intravenous injection of these three barbiturates agreed with laboratory findings in so far as the contrast between amytal and the other two is concerned. Amytal produced, on the aver-

age, much longer sleeping time in proportional doses than did pernocton and ethyl-methyl-butyl barbiturate. The period of depression following pernocton as contrasted with ethyl-methyl-butyl barbiturate, however, did not parallel the differences that were demonstrated in the laboratory. The reasons for this are thought to lie in an insufficient number of cases as well as in the fact that it is more difficult to judge the cessation of a depressed state in the human than in the laboratory animal unless the differences between the drugs are quite marked. The experimental animal gets up on his feet as soon as the effects of the barbiturate have largely worn off, while the human may drift into natural sleep and rarely gives such easily recognizable indices of recovery.

Postoperative excitation and delirium have been occasionally observed with all three of the drugs. The duration of this period, however, was comparatively short with ethyl-methyl-butyl barbiturate and pernocton as contrasted with amytal, again confirming the laboratory findings. The long period of detoxification and depression with amytal and other long acting barbiturates constitutes a serious impairment of their value for surgical purposes. The short acting barbiturates mentioned here represent a distinct improvement and indicate possibilities and direction for further developments.

The availability of pernocton made up in a ten per cent solution is of advantage over the other two that are marketed in ampules of the crystals that must be made up into solution before use. It is possible that the other barbiturates will also be stable in this form.

There seems to be little advantage that can be claimed clinically for intravenous use of one barbiturate over another except in so far as the advantage lies in differences in the duration of depression and in the total quantity of the drug that the organism must destroy or eliminate. Then if the complication ensues that



the individual has a slow recovery as a result of faulty elimination or destruction, that difficulty will obviously be lessened by use of the more powerful and shorter acting drug. As adjuncts to surgical anesthesia, there has seemed to us to be a distinct disadvantage in long acting drugs, especially since the late effect is not one of pain relief, but of drowsiness and lack of cooperation, with the occasional complication of delirious reactions to sensory stimuli.

The immediate pharmacologic effects of the three drugs are apparently identical. A rapid injection results in marked respiratory and circulatory depression. When slowly injected a diminution of respiration is effected simulating that in normal sleep. Slight depression of systolic blood pressure is the rule. Some of the physical signs of depth of anesthesia ordinarily employed with drugs administered by inhalation are inapplicable. As an instance, we may state that the conjunctival and corneal reflexes disappear extremely early when barbiturates are employed. It is possible that a wider clinical experience with the barbituric acid derivatives may develop a group of distinct physical signs that will serve as a guide to their intravenous administration. At present a slow

injection to the point of complete unconsciousness with moderate respiratory depression has been the extent of the guiding signs observed. The reaction to skin trauma may also be utilized.

Our present belief is that the barbituric acid derivatives administered intravenously promise to offer a worthwhile addition to the armamentarium of the physician. We doubt the advantage to the surgeon of the use of those derivatives which result in many hours or days of depression. We believe that the use of the quickly detoxified barbiturates may constitute in the future a very valuable background upon which to superimpose block or general anesthesia. A nervous type of individual can be taken to the operating room asleep. Whether this sleep be induced by the intravenous injection of a barbiturate or by the hypodermic injection of members of the opium and atropine groups, will doubtless be a matter that must be decided on the basis of long and careful clinical comparisons. None of the barbituric acid derivatives at present available appears to be a true anesthetic substance, and hence should not be considered for the replacement of the well established volatile and controllable anesthetic.



# THE PLACE OF ·RADIOTHERAPY IN THE TREATMENT OF THYROTOXICOSIS\*

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THE result of treatment of thyrotoxicosis can fairly well be measured by objective means accurate enough to compare the various methods of treatment in use. We can state with considerable accuracy the effectiveness of treatment in the individual patient, study a group of patients and state in definite percentage figures, the results obtained. We can do this in the case of thyrotoxicosis with greater accuracy than is true of many other serious diseases.

There are certain intangible factors in thyrotoxicosis that are not measurable. In a study of these patients we have no measure of temperamental changes; of feeling of well-being or the reverse; of psychic stability; except in a very crude sort of way, of general physical strength or capacity for work. These are the factors that the competent clinician "sizes up." But after all, these intangible factors follow a very close parallel with the tangible, measurable objective factors which he who runs may read. Of the tangible factors, the most important are the basal metabolic rate, the degree of return to normal body weight, the pulse rate and return to cardiac regularity where irregularity has existed. The clinical picture of thyrotoxicosis is so diversified that no one of these factors can be used as an absolute measure of the toxemia. Undoubtedly, accurate estimates of the basal metabolic rate constitute by far the best single means of estimating the patient's condition. For practical purposes it is a satisfactory guide in measuring up the condition of large numbers of patients. A combination of data on the objective factors mentioned here leaves nothing to be desired

as a basis for study of results of treatment, and for comparison of the various kinds of treatment.

In presenting a study of some hundreds of clinical cases, it is impractical to present protocols such as constitute an essential part of the reports from experimental laboratories. But verifiable data should be given in detail, especially such verifiable figures as those of metabolism. The utter worthlessness of metabolism data when the source is not known and vouched for by the author, is notable.

In papers published by the writer, such data on metabolism were given. Since those papers were published some additional hundreds of metabolism estimates have been made upon these patients. All of these metabolisms were done under the conditions named in those papers, conditions which I regard as essential in any serious contribution to the subject; that is, they were done in my own laboratory, in expert hands, or in laboratories of such standing as to make their findings above question. No data obtained by mail, or from general practitioners, or from outlying hospitals are included. All patients whose metabolisms are done under such uncontrolled conditions are listed separately. They are excluded from the published cases as a matter of accuracy.

In answer to the question which constitutes the subject of this paper, some such data on the results of radiotherapy should be presented by those who favor this method of treatment. They are necessary for a critical study of any presentation. Yet roentgenological literature is peculiarly lacking in this respect. No paper gives diagnostic data; few give sub-

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stantial objective data on which the critical student may base an opinion of results. In many roentgenological contributions, it is apparent from the context that the metabolism data given are quite uncontrolled, or it is stated that the observations were made by the physicians sending the patients for treatment.

Among the more valuable contributions to radiotherapeutic literature, the incidence of cure is rated from 50 to 80 per cent. A frequently recurring error in stating results is to list patients as "improved." Pathologically and prognostically, a patient whose metabolism has dropped from 60 to 30 as the result of any kind of therapy is no more improved than is one whose metabolism has risen from 0 to 30. In either case, such a patient is in urgent need of proper care. On that basis, all improved cases must be listed as failures.

Another factor that is given all too little prominence in roentgenological literature is the time element required for the cure of the patient. In many cases the time factor plays an important part in the organic damage sustained by the patient. It is apparent that much time is required for x-ray treatment, during all of which the patient is in a toxic state. Exception is taken to this statement in an exceptionally valuable contribution by Christie who states that the average time required is five months, and that he has seen no damage develop under treatment. Yet in the same paper he states that much of the "morbidity" and "ravages" of the disease are due to the fact that the duration of the disease averaged "over two years" before the patient came for treatment. Five months is a substantial fraction of two years; if the treatment averaged five months, many of the patients must have remained toxic while under treatment a much longer period; and finally, from the context of his earlier papers, a substantial proportion of his patients remained under treatment more than seventeen months, and were toxic and under treatment at the end of that time.

Radiotherapy has had much advocacy as a preparatory method for bad risk patients. It has seemed to me that iodine given for ten to thirty days has been far superior in its effects and surely much more rapid in action. Patients who have been given iodine over long periods of time seem to become resistant to its action. These may very logically be given the benefit of radiotherapy preparatory for operation.

Very mildly toxic cases, and particularly early adolescent cases often respond readily to iodine, rest, etc. without obtaining complete relief. Radiotherapy may have a place here in making such improvement complete and lasting.

It has been repeatedly suggested that the inoperable cases are best treated by radiotherapy.

What is "an inoperable case?" An accompanying inoperable carcinoma, the existence of any accompanying condition such as advanced tuberculosis, that reduce life expectancy to a minimum. These may properly be considered inoperable. No degree of thyrotoxicosis is in itself a bar to operation. No associated condition, cardiac central nervous, etc., that is not intrinsically incompatible with life, constitutes a contraindication to surgery. If, with the removal of the burden of thyrotoxicosis, life may be expected to be reasonably prolonged, there is no contraindication. These patients may be controlled more effectively within a few weeks with iodine than by prolonged x-ray therapy. Those who have associated conditions incompatible with life may be made more comfortable with iodine, to which x-ray treatment may bring additional aid.

The mortality of thyroidectomy has been reduced to a remarkable low figure. It is below 1 per cent among surgeons competent in thyroid surgery. Its results begin to be apparent within twenty-four hours of the operation. The metabolism approaches the normal within ten days.

Data on the permanence of results are all too few to satisfy the critical student.

Some such figures are about to be published by the writer. The following statement may be made in this preliminary paper.

Among 1000 thyrotoxic patients subjected to thyroidectomy, on whom we have adequately studied and recorded data, obtained under the restrictions mentioned here, *not one* whose metabolism reached normal after operation, and remained normal over more than a single observation, has had a relapse.

Of the small number of patients operated upon by the writer who required reoperation because of a relapse, about 15 patients, *not one* had had a normal metabolism after operation, except possibly for a single observation. Though clinically cured, actual metabolism studies showed that they were cases of technical failure due to an inadequate thyroidectomy. In each case the secondary operation revealed an excess of thyroid tissue overlooked or the amount left underestimated at the primary operation. These were not relapses, but errors of operative technic.

Of over 50 patients operated upon elsewhere, who came under observation for what was supposed to be a relapse, many with a history of clinical cure before the relapse occurred, very few had had their clinical condition checked up with metabolism studies. Of this few, *not one* had had a normal metabolism for more than a single observation. Yet this type of patient is often regarded as evidence of the failure

of surgery instead of the failure of the particular surgeon concerned. Under these circumstances, adequate thyroidectomy must be granted to insure an almost perfect freedom from relapse.

The utterly uncritical spirit in which these failures are regarded in radiological literature is most unfortunate. Thus an outstanding roentgenologist refers to a patient whose metabolism fell from +115 to +112 after operation as having had a "subtotal" thyroidectomy! Of course the veriest tyro in physiology would have known the type of surgery to which that patient must have been subjected. The further statement that many of his patients had a higher metabolism after thyroidectomy than before does not justify serious discussion.

#### SUMMARY

Radiological literature relating to the treatment of thyrotoxicosis is extremely meager in adequately controlled objective data on which the student may base an opinion. Even on the basis of this inadequate study, from 20 to 50 per cent of failures are commonly admitted.

Very mild, early, adolescent cases and patients with associated lesions incompatible with a reasonable life expectancy, may advantageously be given radiotherapy.

Radiotherapy offers no advantage over a short course of iodine as a preparatory method of treatment.



# NON-SURGICAL TREATMENT OF HYPERTHYROIDISM\*

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THE treatment of the syndrome usually called exophthalmic goiter or hyperthyroidism has gone through a number of changes since the initial efforts, especially of Kocher. His results, due to a removal of too much thyroid and parathyroid, caused a loss of enthusiasm in the surgical treatment which has, however, reappeared in recent years especially since the successes of such men as Crile and the Mayos. The question of treatment and end-results revolves very largely upon the criteria that are used in evaluating the amount of the patient's involvement. The almost universal use of the basal metabolic test has resulted in its being considered as the principal criterion as to cure. Other factors are the reduction in pulse rate, and one that is quite generally overlooked, gain in weight. These are selected because other evidences of cure are of such an individual nature that it is very hard to compare statistics with a rigid differentiation as to the amount of involvement.

Nevertheless, in the actual dealing with the patient there are many symptoms of which he complains that are not indicated by any one or all of these criteria. Many patients will show normal metabolism, normal pulse rate and moderate to excessive gain in weight, and still be far from well. It has seemed for a long time that this warrants the idea which has been set forth by Warthin and others, that we are not dealing with a disease that is restricted to the thyroid, but rather a constitutional disease, and that by the removal of the thyroid or its over-activity, whether by surgery, x-ray, the injection of boiling water or other destructive substances, or even by rest, we produce a remission of the disease very similar to the remission produced in pernicious anemia by liver

therapy. As in pernicious anemia with liver therapy, the achylia and nerve symptoms may continue in the presence of perfectly normal blood picture, so in thyroid, although laboratory tests may be perfectly normal, we still have a group of much more indefinite symptoms that often continue. These are best illustrated by the following case history.

CASE I. Mrs. H., aged thirty-five, had been under observation for a number of years because of an old rheumatic mitral disease. She returned with an obviously marked exophthalmic goiter. The onset was insidious during the past three months, with a loss of 15 lb. in weight, increasing weakness, nervousness and fatigue. There were the usual toxic symptoms of free sweating and a number of attacks of diarrhea. Basal metabolism at this time was +75. Against my advice she elected operation and this was done by a well-known thyroid surgeon who did what is termed a subtotal thyroidectomy, without the removal of the parathyroid tissue. Within ten days basal metabolism was reported to be +1. She was kept under observation by the surgeon for a period of three months, during which time she gained in weight, had a normal pulse rate and continued with normal metabolism. When seen at this time she complained of an indefinite train of symptoms best expressed by her as "not feeling her normal self." These consisted of easy fatigue, lack of energy and sleeplessness. She volunteered the statement that she had felt much better at the height of her toxemia than she now felt. Careful examination revealed muscle irritability, a positive Chvostek and muscle cramp. Blood calcium determination gave 10 mg. per 100 c.c. of blood. The administration of 60 grains of calcium lactate in milk, with an equal amount of lactose per day, produced slight changes in the tetany. Because of the well-known physiological fact that thyroid increases calcium metabolism, she was given 2 grains of thyroid daily. This resulted in increase of blood calcium to 12 mg. per 100 c.c.

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and complete disappearance of the signs of tetany. The administration of thyroid made no change in metabolism. The other symptoms showed very slight improvement and it was not until after eighteen months of this treatment that she felt able to return to her duties as a bookkeeper. She has never had a return to a sense of complete well-being.

It has been noticed many times in individuals with very great reduction of the thyroid rate, that the giving of a sufficient amount of thyroid to bring metabolism to normal often results in complaint by the patient that they do not feel as well under medication as without it. Going on the assumption that these patients find it impossible to readjust their sense of life suddenly from low metabolism to normal or slightly above normal rate, we have found treatment much more satisfactory when thyroid therapy is very gradually increased, so that instead of reaching normal basal metabolism within a short time, a period of a year or more is allowed elapse. It would appear logical that the same thing may occur in individuals who have been used for varying periods of time to very marked increase in the metabolic rate, namely, that a sudden reduction of this rate to normal or less than normal requires a varying period, often a long one, for a readjustment of the individual to bodily sensations that occur with a normal rate.

The principal claim of surgery to treatment of hyperthyroidism is, first, its immediate and permanent eradication of the toxemia, with a practically negative mortality rate in the hands of skilled operators. This prompt cure would appear to be extremely important to individuals whose economic status is such that they are unable to stand a prolonged illness. But if it takes a year or more for these patients to return to a normal sense of well-being, it may then be seriously questioned whether surgery does so promptly eradicate the disease.

A second argument in favor of immediate removal of the thyroid is that a

continuance of toxic thyroid symptoms means an increased serious damage to the heart muscle, so that non-operative treatment may cause a symptomatic recovery with a very serious cardiac lesion left as a residue. Observation of a number of cases with severe cardiovascular involvement treated by x-ray has convinced me that the prolongation of treatment by x-ray does not increase cardiac damage, and that the ultimate recovery of cardiovascular symptoms is just as good under this form of therapy as any other.

Although in the hands of an expert operator the mortality from surgery is extremely low, the probabilities are that the mortality statistics from the country as a whole, in the hands of all operators, would be considerably higher. If this be true, then a third reason for the use of conservative means against surgery is that of reduction of mortality.

The remission is produced by destruction of the gland, regardless of the manner in which it is destroyed, and often a remission may be produced without active interference with the gland. Neisser, Ewy, Spengler, in European clinics, Solomon Straus in America, have suggested in certain types of moderately toxic thyroid, the use of bed rest, with very small doses of iodine 2 to 2.5 mg. daily. These authorities have all reported favorable results under this method of treatment.

This treatment is especially applicable in girls and women, and occasionally in men in whom a prolonged illness is not a serious economic factor. If a carefully selected group such as this is kept under observation for a year or more, by far the greater number may avoid any destructive type of therapy.

In our own experience we have a series of 42, mainly young girls and young pregnant women, with basal metabolic rates as high as +35, who on small doses of Lugol's solution, 5 to 6 drops a day over long periods of time, have shown complete remission of their toxic symptoms with no return for periods varying from one

to two years. In more toxic types and in those in whom small doses of Lugol's solution fail to produce recovery, the gland may be destroyed with a varying degree of rapidity by the use of irradiations with x-ray. E. L. Jenkinson, of Chicago, in a personal communication, recently stated that in 600 cases treated only by x-ray, 80 per cent have remained free from abnormal basal metabolism or pulse rate. He believes that very often only a small part of the thyroid is involved in a pathological process, and that the destruction of this particular part results in a cure, regardless of the remainder of the thyroid.

Groover, Christie<sup>1</sup> and their co-workers report a series of 305 cases treated exclusively by x-ray. Their criteria for recovery is that of gain in weight and lowering of basal metabolic rate. In this group 37 were mild, 157 were moderate, and 111 were severe; after treatment, 271 were considered as cured, 88.85 per cent; 26 were

<sup>1</sup> GROOVER, T. A., CHRISTIE, A. C., MERRITT, E. A., COX, F. O., McPEAK, E. M., Roentgen irradiation in the treatment of hyperthyroidism. *J. A. M. A.*, 92: 1730, 1929

improved, 8.52 per cent; and 8, or 2.63 per cent, were unimproved. In this group there was not a single case of injury to the parathyroid, although this has rarely occurred as a consequence of large doses of radiation, in the hands of others.

In a small series of personal cases we have had only one that has not given satisfactory results with radiation (Case 11).

CASE 11. A woman of fifty gave a history that could be explained as a chronic hyperthyroidism with periods of remission and exacerbation, extending over some twenty years. When first seen in January, 1928, she was suffering the most severe exacerbation she had experienced. There was a loss of 10 lb. in weight, a chronic diarrhea of two months' duration, extreme nervousness and sleeplessness. Her thyroid was moderately enlarged and distinctly nodular. A moderate exophthalmus was present, and also a fine tremor of the hands and tongue. The apex of the heart was in the anterior axillary line. At rest the heart rate ranged around 120 per minute. Basal metabolic rate at this time was 38.6. She was given a series of x-ray treatments as shown in the following table:

TABLE 1

Date	Area	Filter, Mm.	Voltage, Kv.	Skin Focal Distance, Cm.	Milli-amperes	Time, Minutes	B.M.R.
2-29-28	Ant. thymic	6 Al.	125	12	5	12	47 8
3- 1-28	Right thyroid	6 Al.	125	12	5	12	
3- 1-28	Left thyroid	6 Al.	125	12	5	12	
3-21-28	Ant. thyroid	4 Al.	105	12	5	7	43 6
3-23-28	Ant. thyroid	4 Al.	105	12	5	7	
5- 2-28	Ant. thymic	1 Al.	75	15	5	5	27 2
5- 3-28	Right thyroid	1 Al.	75	15	5	5	
5- 3-28	Left thyroid	1 Al.	75	15	5	5	
10-17-28	Ant. thymic	1 Al.	75	15	5	6	38 6
10-18-28	Right thyroid	1 Al.	75	15	5	6	
10-19-28	Left thyroid	1 Al.	75	15	5	5	
11-19-28	Ant. thyroid	4 Al.	105	15	5	7	37
11-22-28	Ant. thyroid	4 Al.	105	15	5	7	
12-20-28	Ant. thymic	1/4 Cu. 1 Al.	125	15	5	15	32 8
12-21-28	Right thyroid	1/4 Cu. 1 Al.	125	15	5	12	
12-21-28	Left thyroid	1/4 Cu. 1 Al.	125	15	5	13	
1-11-29	Ant. thymic	6 Al.	125	12	5	10	29 7
1-22-29	Right thyroid	6 Al.	125	12	5	8	
1-23-29	Left thyroid	6 Al.	125	12	5	8	

After her return from her summer vacation, September 29, her basal metabolism was normal, and she had gained 15 lb. in weight. Her heart was still dilated, and there was some dyspnea upon exertion. When she was seen within the past week, the cardiac symptoms had disappeared and she considers herself as completely well.

As to the differentiation of hyperthyroidism into the adenomatous type or the exophthalmic type, many authorities do not feel that an accurate diagnosis can be made. Christie has concluded that the results of x-ray therapy are the same in both types, and my personal experiences agree with these conclusions. Besides active treatment, the patient should be kept as near bed rest as possible, if at all toxic.

toxic cases are treated as ambulatory cases, and among the men practically all continue at their work.

CASE III. Mr. L. consulted me on May 11, 1929 because of nervousness, fatigue, weakness and rapid loss of weight. He showed the classical symptoms of an exophthalmic goiter. These symptoms had been noticed during the past month. His first basal metabolic rate was 38.7, pulse 110.

His business is of such a nature that his entire year's income is derived from three months' work during the summer. During this period he travels considerably and regularly works eighteen hours a day. The occurrence of symptoms at this time made any treatment other than ambulatory impossible. He was hospitalized one week, given Lugol's solution, 45M per day, and received his first x-ray treatment May 31, 1929:

TABLE II

Date	Area	Filter, Mm.	Voltage, Kv.	Skin Focal Distance, Cm.	Milli-amperes	Time, Minutes	B.M.R.
5-31-29	Right thyroid	5 Al.	118	23	5	5	38.7
5-31-29	Left thyroid	5 Al.	118	23	5	5	
6-1-29	Ant. thymic	5 Al.	118	25	5	5	
6-27-29	Right thyroid	5 Al.	125	30	5	7	
6-27-29	Left thyroid	5 Al.	125	30	5	7	
6-28-29	Ant. thymic	5 Al.	120	30	5	7	

The average duration of treatment is approximately four months in the more toxic type of cases. It is preferable that the first series be given with the patient in the hospital at bed rest. It has been our custom to prepare them for x-ray therapy with large doses of Lugol's solution, as for surgical operation. With reduction of the symptoms therapeutic x-ray is given over a period of two or three days, depending on the toxemia of the patient. If there is no reaction and the patient is not extremely ill, he is allowed to be ambulatory until the next series of irradiations. Usually after the second series he can be treated as an outpatient, and many can return to work. All moderate and mildly

It became more convenient for him to continue his treatments nearer his office, accordingly the following 4 series were given in a downtown office:

He continued to work at high tension during this entire period. After July 1, 1929, the nervousness, weakness and rapid pulse were greatly improved, but no gain of weight occurred until he was able to stop his work in September. A recent report was that of normal weight and apparent complete recovery. His basal metabolic rate is now +5.

It is unquestionable that there is a distinct place for both surgery and medical treatment of hyperthyroidism, with the majority of patients probably being better off on medical therapy than on surgical therapy, but I feel quite sure that in the



future our ideas of so-called hyperthyroidism will have changed so completely that all our present theories as to therapy will be discarded.

TABLE III

Date	Area	Filter, Mm.	Voltage, Kv.	Skin Focal Distance, Cm.	Milli- amperes	Time, Minutes	B.M.R.
8- 9-29	Right thyroid	4 Al.	120	11	5	6	
8- 9-29	Left thyroid	4 Al.	120	11	5	6	
8-12-29	Right thymus	4 Al.	120	11	5	6	
8-12-29	Left thymus	4 Al.	120	11	5	6	
8-16-29	Posterior neck	4 Al.	120	11	5	6	
8-30-29	Right thyroid	4 Al.	120	11	5	6	
8-30-29	Left thyroid	4 Al.	120	11	5	6	
9- 1-29	Right thymus	4 Al.	120	11	5	6	
9- 1-29	Left thymus	4 Al.	120	11	5	6	
9- 5-29	Posterior neck	4 Al.	120	11	5	6	
9-23-29	Right thyroid	4 Al.	120	11	5	6	
9-23-29	Left thyroid	4 Al.	120	11	5	6	
9-27-29	Left thymus	4 Al.	120	11	5	6	
9-27-29	Right thymus	4 Al.	120	11	5	6	
9-30-29	Posterior neck	4 Al.	120	11	5	6	
10-14-29	Right thyroid	4 Al.	120	11	5	6	
10-14-29	Left thyroid	4 Al.	120	11	5	6	
10-16-29	Left thymus	4 Al.	120	11	5	6	
10-16-29	Right thymus	4 Al.	120	11	5	6	
10-18-29	Posterior neck.	4 Al.	120	11	5	6	



# RADIOTHERAPY

## ITS PLACE IN THE TREATMENT OF TOXIC THYROID DISEASE\*

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WHAT is the best treatment for exophthalmic or toxic goiter? This question is asked frequently by patients who suffer from this condition. Judging from the voluminous surgical literature on the subject, the casual reader feels that surgery is the answer. However, radiologists who have given the question much thought and who have reviewed their own results, feel that radiotherapy must be given thoughtful consideration. Inasmuch as toxic goiter is a disease of questionable origin, we must agree that there is no specific treatment. Surgery cures by excising a major portion of the hyperactive gland, while irradiation by x-ray or radium produces a similar effect by decreasing secretory activity of the individual cell in the gland. Neither method has shown itself successful in all cases, but surgery has made patients well who have shown little or no response to radiotherapy, while irradiation has cleared up cases that were still toxic after one or more surgical attempts.

The earliest use of the x-ray in exophthalmic goiter is recorded by Williams and Pusey, two outstanding American physicians, who reported marked improvement following its use in this condition. At about the same time, two German investigators, Stegman and Goel, noted the lasting effects observed after the roentgen ray was administered to patients with this disease, and Charles Mayo, who speaks today with authority on surgical treatment, reported that x-ray therapy was valuable in preparing toxic patients for operation. In 1905, Abbé, a New York surgeon, began to use radium with success in patients of this type. Since those days, many other men throughout the world have reported their experiences. The out-

standing articles have been written by Allison, Erskine, Dunham, Forssell, Hayes, Henry, Holmes, Holzknecht, Jenkinson, Loucks, Pfahler, Soiland, Swanberg and Trostler. A careful review of their writings will convince the most skeptical that in radium and x-ray we have weapons which, if not considered as rivals, at least are valuable adjuvants to surgery in toxic thyroid disease.

Not all patients who present themselves are suitable for radiotherapy. There must be a careful selection to eliminate those with simple colloid goiter and those with adenomata. These patients complain of enlargements and pressure symptoms, and can only be relieved by surgical intervention, since irradiation will produce little if any diminution in the size of the gland. However, if a patient is suffering from a toxic adenoma and has refused operation, or if operation is contraindicated, there is no objection to treatment, as there is a good assurance of diminishing the toxicity even though there is no change in the size of the palpable lobes.

To insure a proper conception of suitability and cooperation on the part of the patient, the following points should be stressed:

1. Careful history and examination to know that a toxic goiter is the basis of symptoms.

2. Verification of the degree of toxicity by basal metabolic readings.

3. Eradication of foci of infection which may be the underlying predisposing cause of the toxicity.

4. Institution of irradiation with the following reservations and explanations to the patient:

- (a) Irradiation causes a diminution of

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toxicity but it can in no way remedy existing vascular or neurologic defects already present.

(b) Irradiation effects are slow in their manifestation, so that patients must cooperate and be under observation for at least a year.

(c) Institution of rest and quiet in advanced cases, and the administration of such suitable medication as is indicated for complications and sequelae that may already exist.

(d) Metabolic readings during the course of treatment to prevent over-irradiation.

If these suggestions are observed and followed, there will be little chance for failure.

Every kind of treatment has its drawbacks. Irradiation of the thyroid has run the gamut of objections, but the principal one is the occurrence of so-called burns. It is true that a radiodermatitis is seen after treatment occasionally, and in the days when radiotherapy was in its infancy, when little or nothing was known about filters, this was a legitimate objection, but under present conditions, such an occurrence is a rarity. Accidental omission of filters may be followed by dermatitis, but has its counterpart in the accidental cutting of a recurrent laryngeal nerve during thyroidectomy.

Another argument against radiotherapy is the danger of myxedema. This is a real danger, and it must be admitted that intensive prolonged irradiation results in hypothyroidism. However, removal of too much thyroid tissue will do the same thing. If frequent metabolic readings are made during the course of treatment, the occurrence of myxedema will be infrequent. When the rate drops to plus 15 per cent, no more exposures should be given until a period of six or eight weeks have passed to note whether the rate is dropping further or is rising again.

The last objection raised is the increased difficulty of operation when irradiation fails. Prolonged irradiation, especially with soft rays, may result in fibrosis, but

the fibrosis resulting is no different from that caused by applications of iodine and hot water injections. Although the oozing may be increased, the surgical risk is less, since it is admitted that irradiation reduces the degree of toxicity. Careful selection of patients, and the abandonment of prolonged radiotherapy where symptoms are not improved, will eliminate this phase.

If these, then, are the objections, what are the advantages of radiotherapy? In the first place, the treatment per se carries no mortality. We agree that in the hands of the expert surgeon this is very low, but in the hands of the occasional surgeon it is still high enough to warrant consideration of other types of treatment. Our modern existence is governed by economic conditions. In recommending one or another form of therapy in toxic goiter, this must be borne in mind. In other words, how long will it take until the wage earner is back at work and how much will his regular routine of life be disturbed? Much of the irradiation is given to patients who are ambulant; that is, they are home patients rather than hospital patients, and they continue their work if they are not too toxic. Judged from this standpoint, a patient treated by irradiation suffers less disturbance of home life, with less expense, than one submitting to the surgery. However, this should not necessarily be an argument for radiotherapy, for if financially able it is just as advisable for a real toxic patient who is receiving radiation therapy to spend a short time in the hospital as it is for one who is being prepared for operation. Thus, the number treated by radiotherapy who need hospital care is materially less than those submitting to surgery.

In the early part of this paper we mentioned that no treatment is 100 per cent successful. Radiotherapy has its failures, and the consensus of opinion is that these are due to:

(a) Lack of cooperation on the part of patients. They tire of waiting for results and submit to other forms of therapy.

(b) Improper diagnosis.

(c) Lack of radiosensitivity.

The latter patients belong to a class indistinguishable from others with general toxic symptoms and increased metabolic rates, who show no response to radiation. There has been much speculation as to the cause of this failure of response. Radiologists who are using harder forms of *x*-ray generated from 180 kv., filtered through copper, feel that a change in technic from moderate voltages of 135 and 140 kv. to 180 or 200 kv. will eliminate some of these failures. Likewise, radium enthusiasts seem to have more success than those using the *x*-ray. Possibly a change in technic as is being used in the treatment of malignancy, with harder rays, prolonged exposures and higher filtration, will give the desired effects.

To get at the actual results, we have studied a series of over 3100 cases treated by radiotherapy, reported by twenty different observers. This study gave the following results: Seventy-three per cent

were clinically well, they showed no evidence of thyroid disease clinically or metabolically; 16 per cent were improved; 11 per cent were unimproved and must be considered radiological failures. Included in these 3100 cases were 400 patients treated with radium by one observer alone. Ninety-eight per cent were clinically well following the use of gamma radiation, which seems to verify the comments made in the paragraph preceding that a recourse to harder radiation will attain more perfect results.

In view of the foregoing presentation, we feel that the results of radiotherapy in exophthalmic or toxic goiter compare favorably with those obtained by surgery. Happily, patients who do not get relief from one method of treatment are benefited by the other. For this reason, we are of the opinion that it is justifiable to advise the use of irradiation in toxic thyroid disease, and if failure results, operation can still be carried out since the surgical risk is not increased.



# CHOLECYSTITIS

WITH AND WITHOUT CHOLELITHIASIS\*

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IN the course of the lifetime of the busy physician and surgeon, certain phases of his chosen profession seem to receive much more thought and attention than others. Since the day of specialization is at hand, it is but fitting that we at this time show some specific study and thought along lines that are of special interest to us. It is because of this interest and study that I have chosen to present one of the common causes of digestive symptoms, a complex of symptoms exceedingly numerous. I refer to diseases of the gall bladder and ducts. The frequency with which this organ is affected cannot be ascertained since it is estimated that most of the human race at some period of their life, suffer from some one of the many pathological conditions of this organ. Neither males nor females seem to be immune, although it is found in women more often.

It is because of the many cases of so-called dyspepsia and indigestion which have proved to be caused by pathological conditions of other organs, that I present a few cases of cholelithiasis. Space will permit but a cursory introduction to this subject concerning which volumes have been written. That stones should develop at all in the human anatomy seems a phenomenon almost unbelievable. Seeing, however, is believing and we have all seen them many times. I will simply mention a few of the causes which are necessary for the formation of gallstones.

Cholelithiasis is a most common disease, much more common than was formerly supposed. Many cases of so-called gastralgia, acute and chronic indigestion, ulcer of the stomach, diseases of the pancreas and appendicitis prove to be gallstones. Osler states that gallstones are found at autopsies in from 5 to 10 per cent of all

cases that die of other causes. If this be true, what a common malady it is! It is true that other diseases affecting the pylorus, the duodenum, or the head of the pancreas are sometimes diagnosed as gallstones. Unless there are very positive signs of cholelithiasis it is often very difficult to make a positive diagnosis. The x-ray and fluoroscope are at times valuable aids in diagnosis. There are cases of gallstones that give absolutely no symptoms of the disease. A stone or stones may remain quiescent in the gall bladder for a long time. This is shown to be true by the fact that they are found at operations and autopsies.

The formation of these stones is an interesting process concerning which much has been written and a great many theories expounded. The accepted view today is that there are two primary factors which must be present: (1) some interference which causes either a stasis or impediment to the free flow of bile; (2) some kind of bacterial infection. It is necessary that both these conditions be present; the one without the other is not sufficient. It is generally a mild catarrhal inflammation which distorts and either closes or partially closes the cystic or hepatic or common ducts and thus produces the first necessary cause, namely, some interference with the free flow of bile. The reason that gallstones do not form when there is a free flow of bile is that there is no stagnation of bile and the inroad of infection is cut off by the flow of bile washing bacteria back into the intestine. The second cause, that of infection, is produced by many kinds of bacteria, some of the most common being the *Bacillus coli communis*, the *Bacillus typhosus*, *Staphylococci pyogenes aureus* and *albus*. Cases are also recorded

\* Read at the Scientific Meeting at the Onondaga General Hospital, Syracuse, N. Y., October, 1929.

where the infection was produced by the pneumococcus and by the bacillus of influenza. There are many avenues by way of which these germs are carried to the gall bladder. They may enter from the duodenum through the common duct or the portal circulation, and the hepatic artery may carry them to the gall bladder, or they may enter from the peritoneum through the walls of the gall bladder itself. It is seldom that infection takes place from the duodenum because, if the duodenum is in a normal condition it is supposed to be sterile. Any disease of the duodenum favors infection of the gall bladder by extension of the trouble through the common duct. One of the most common ways for infection to be carried is by the portal vein and the most common organism found is the colon bacillus. The *Bacillus typhosus* may enter through the circulation from the blood or direct from the intestinal tract.

Cholelithiasis is a subject which is of vital importance and interest to both physicians and surgeons. It is of interest to the internist from the diagnostic point of view. I believe the condition a surgical one and that treatment should be surgical. It is not rare to find in cases of gallstones, with chronic cholecystitis, that ulceration of the wall of the gall bladder takes place to such a degree that the gall bladder may rupture, throwing the stone or stones into the peritoneal cavity, or that cholecystoduodenostomy and cholecystogastrotomy have been performed by nature.

The size and the number of the stones vary greatly. Merkel found one that weighed 120 gm. As many as 7802 stones have been found in a single case reported by Otto.

I will not enter into the discussion of the predisposing causes or of the medical treatment, if there be such a treatment.

CASE 1. This case is a most extraordinary one from a surgical point of view. Mrs. S. aged forty-nine, born and reared in England until she was twenty-three years old. Father died at the age of forty-two with pneumonia,

the mother at the age of fifty-three of heart disease. There are four brothers and three sisters all living and well at the present time. Patient married at the age of twenty-two, has three children. Lived in Canada three years and six months, when she moved to Syracuse and has lived here ever since.

About two years after coming to Syracuse she had her first sickness. Was taken with what was then called inflammation of the bowels, probably appendicitis with perforation of the appendix, producing a general peritonitis; was critically ill for ten weeks when she began to improve and was finally able to be up and about but never fully recovered. Following this sickness she consulted another doctor who, after examining her, told her she had a tumor of the womb and advised operation for its removal. She was removed to the hospital and the tumor removed. Made a good recovery. About six months after she began to be troubled with obstinate constipation, often going for a week at a time without evacuation. It was in such a condition as this that she was taken violently ill with intense pain in the abdomen. All the ordinary methods of producing catharsis were resorted to, but to no avail. It was impossible to get any response from the bowels. Finally it was decided to remove her to the Hospital of the Good Shepherd, where she was operated on for intestinal obstruction and a portion of the intestine removed. From this operation she made a good recovery. About four weeks after leaving the hospital she took a severe cold. During a coughing paroxysm she felt something give way in her groin and she began to have great pain; was again removed to the hospital and operated for femoral hernia. Two years after she developed a lipoma on her left shoulder. It grew very rapidly in size, so large that it interfered with the movements of her arm, so she decided to have it removed, which was done.

December 16, 1904, I was called to see her. She had fallen the day before and injured her left wrist. Upon examination I found she had a Colles's fracture which was reduced by the usual methods.

March, 1904, she again consulted me concerning a pain in the stomach. She said pain would come on most any time independently of whether she had eaten or not. Said she had had this pain off and on ever since she had inflammation of the bowels some twenty

years before. At first the pain was mild in character and did not cause her much inconvenience. The pain had gradually increased in severity until now sometimes it seemed as if she would die. Pain was right in the stomach. The attacks would sometimes hold off for several months and then she would have another spell. It would begin with loss of appetite, even the smell of cooking food would nauseate her; then she would begin to vomit and would be deadly sick, cold perspiration standing out on her forehead. She would be very dizzy. The pain in her stomach would be paroxysmal in character and so severe that she would have to get on her hands and knees. The character of the vomitus would be stringy mucus mixed with bile. Vomiting would not in any way relieve the pain. External applications and also medication, even morphia administered hypodermically, would not relieve her. On physical examination heart and lungs were found to be normal. Abdomen revealed scars of former operations, aside from which I could detect nothing abnormal. Liver was slightly enlarged. I could not palpate the gall bladder, neither could I outline it by means of percussion. Urine: sp. gr. 1025, acid, no albumin, no sugar. Bowels irregular.

*Diagnosis:* Catarrhal gastritis, suspicious of gallstones. I restricted her diet as to quantity and allowed only foods that could easily be digested. I also told her that she should not work so hard. She was doing all kinds of work, from washing clothes to pitching hay; in fact, I think she could tire out almost any man. Medical treatment was directed towards aiding digestion. She seemed to improve under this line of treatment. I treated her in this way for about a year.

September 3, 1906, I was hurriedly summoned. Upon my arrival at the house I found the patient suffering agonizing pain. She could not keep still; would pace up and down the room; wringing her hands, at times even falling to the floor in her intense suffering. My first thought was to relieve her as quickly as possible so I injected  $\frac{1}{4}$  grain of morphia immediately, then gave her a few whiffs of chloroform. In about one half hour she began to be somewhat relieved so that it was possible to make a physical examination. I found the abdominal wall tense and board-like. The right rectus muscle was especially noticeable, standing out above all the other muscles. There was pain and tenderness over the whole

right side of the abdomen. There were no points where the pain was more severe than in other points. The whole right side of the abdomen seemed involved. The tongue was coated, there was nausea and vomiting. She was unable to retain anything in her stomach. The vomiting was persistent, lasting three days, during which time the pain was incessant, at times more severe than at others. The temperature ranged from 101°F. to 103°F., pulse from 110 to 120, respirations, 26. At no time was there any jaundice, neither had she ever had any jaundice. The condition, as before stated, lasted for about one week. September 9, or about one week after the onset of the sickness she was removed to the House of the Good Shepherd. The day after her condition began to improve. A positive diagnosis was not made but gallstones was the prevailing opinion.

The following day a cholecystectomy was performed by me. The gall bladder showed thickening from the frequent exacerbations of cholecystitis. The gall bladder was completely filled with three large stones and six small ones and pus. The cystic duct was entirely occluded. Gall bladder was so full of stones and pus that when incised the pus flew out in a stream of some distance, so great was the pressure within. Had this case not been relieved by operative interference the gall bladder would have burst, throwing the gallstones and pus into the abdominal cavity with probably fatal results. The patient made a speedy recovery and today is in good health.

As we look over the foregoing history there are several points which impress themselves upon us: first of all, the length of time this patient had gallstones. The thickness of the gall bladder and the size of the stones suggest this. In my opinion the trouble in this case started when she was a young woman suffering from frequent attacks of gastritis which became chronic, the condition extending into the duodenum and thence into the common and cystic ducts of the gall bladder. If this be true we have one of the necessary causes of stone formation, the swelling and thickening of the mucous membranes producing an impediment to the free flow of bile. The other necessary cause, that of infection, arose when this case had inflammation

of the bowels, which was probably caused by the ruptured appendix producing general peritonitis. This patient had many other severe illnesses, and yet no one ever discovered the gallstones or the cholecystitis. The treatment had been for the catarrhal stomach condition.

Again we find this disease in a woman who worked for a living and at hard manual labor. We are told in textbooks that this condition is rare in an active person, in fact, sedentary habits are a predisposing cause of the disease.

CASE II. Mrs. C. of Buffalo, has always been in good health except for frequent bilious attacks. Sometimes would go months without any digestive symptoms or bilious attacks. These attacks she attributed to nervous exhaustion. Is never affected unless she has attended some particular meeting or convention in which she has had an important part, either in discussion or paper reading. It was while attending a convention in this city that this patient came under my care and attention. These so-called bilious attacks would generally follow mental excitement and worry. They would begin in the epigastrium, this discomfort increasing until she would become extremely nauseated and finally vomit. Several years ago vomiting would relieve her and if proper care was taken of her food she would steadily improve and convalescence would be short. She has thus suffered this kind of attack for many years.

She had a rather strenuous week in Syracuse attending a convention and had retired for the night when she felt pain in the stomach and was nauseated; consequently she drank some hot water and some soda and began to vomit. She vomited at intervals all night and the following day without relief. She was removed to the Homeopathic Hospital for careful observation, the vomiting continuing. There was general abdominal pain and tenderness. The abdominal wall was now becoming tense. Pain and tenderness marked over the appendix and gall bladder. Blood count showed leukocytes, 12,000. I advised operation which was refused. Doctor J. W. Candee was called in consultation. He also advised operation and immediately. After much discussion the patient agreed to be operated.

Consequently, at 8 P.M. I removed an acutely

inflamed appendix. Believing the frequent attacks of indigestion and also the bilious attacks to be due to the trouble in the gall bladder, the right rectus incision was carried up so as to expose the gall bladder. Bringing the gall bladder up into the incision, it appeared somewhat increased in size and very hard, the gall bladder was filled with stones and the internal pressure greatly increased. A trocar and cannula were introduced and about 6 in. of thick bile removed. An incision was now made into the gall bladder and 5 large stones about the size of hickory nuts were removed. In the cystic duct were 3 smaller stones. These were removed through the gall bladder. Rubber tube drainage was introduced in the usual manner and the incision closed. Recovery was uneventful except that she developed phlebitis of both legs.

CASE III. Patient thirty-three years of age. Family history negative. Two brothers and two sisters living and well. Married and no children, and no female trouble to her knowledge. Menses regular and normal. Has complained for the last five years of attacks of indigestion so-called. Would be taken with pain in the pit of epigastrium and would vomit. Vomiting would relieve her, but now she says the more she vomits the more she feels like vomiting. The nausea is continuous. Pain is also constant, not free from pain at any time in these attacks. Had been under the care of many doctors and had a great deal of treatment for digestive disturbances. She would finally improve and recover. It was during such a sick spell as this that I was called in consultation. Physical examination revealed an abdomen hard and tense, with general abdominal pain and tenderness, temperature 101°F., pulse 110, blood count showed marked leukocytosis. I advised removal to hospital and operation. Diagnosis, acute cholecystitis and possible gallstones. She was removed to the Homeopathic Hospital and the high incision parallel to costal cartilages of the right side made, the gall bladder exposed and opened. It was filled with very thick bile mixed with pus. The cystic duct was entirely occluded by a single stone. This I removed through the gall bladder and the usual large size rubber tube drainage was used.

I have briefly reported these cases of cholelithiasis to show how frequently these



common cases of so-called dyspepsia and indigestion prove to be gallstones.

I believe in routine examinations of the gall bladder. In cases requiring the opening of the abdomen, when there is no contraindication, the gall bladder should always be examined to discover the presence of stones, to ascertain whether or not it is collapsible, to discover adhesions aptly called by Morris "cobwebs in the attic of the abdomen,"<sup>1</sup> to see whether the wall of the gall bladder is thickened from attacks of cholecystitis and to search for any other pathological conditions around the gall bladder which influence it from without.

Who opens the abdomen today who does not examine and remove the appendix? Pathological or normal, the appendix is removed unless there is some reason for not doing so.

I am just as firm a believer in examinations and treatment of the pathological conditions of the gall bladder. Should any be found I think the time to treat these cases is at the first sitting, so-called, that is, providing there is no contraindication. In this way many second operations could be avoided. In many cases of cholelithiasis the symptoms are not in the gall bladder. You do not have to suffer from an attack of biliary colic to have gallstones. Colic formerly was supposed to be produced by the passage of the stone. Of course this might cause severe pain varying with size of the stone and condition of the ducts. Seldom have stones been found in the feces following an attack of biliary colic. We believe the intense pain and agony to be produced by the violent peristalsis. The gall bladder and ducts, endeavoring to rid themselves of the stones or viscid bile, contract so violently that colic is produced, called biliary colic.

This idea is further substantiated by the fact that gallstones are found in feces where there has been no colic or pain, proving that their passage has been painless. In the great majority of cases of gallstone disease you have, at some particular time and generally at irregular intervals, attacks of

intense, agonizing, unendurable pain commonly called gallstone colic. The picture of a patient afflicted with gallstone colic is common to us all and a further description will not be given. It is these attacks of excruciating agony that bring these cases as a rule to the surgeon.

Concerning the treatment of these cases, when the stones are confined to the gall bladder, there is a difference of opinion, some favoring cholecystectomy; others claim cholecystotomy and drainage to give the best result.

My method has been to perform cholecystectomy unless there is some contraindication, such as in the very old, and feeble, or where for anatomical reasons the removal of the gall bladder would be fatal. I have chosen these cases to show the different clinical pictures presented.

In the first case we have a patient that was unfortunate enough to have had her abdomen opened on more than one occasion and with a gall bladder full of gallstones causing digestive trouble continually and yet undiscovered and unrelieved; a typical picture of gallstone disease with the colic, vomiting, shock, etc. I know that many times while operating, conditions arise which make it impossible to do all that the surgeon thinks necessary. In such cases it is excusable to wait until some further time. I think it is the duty of the surgeon to tell the patient of the existing pathology and recommend further operation. I believe it the duty of the surgeon to make a thorough examination of the abdominal contents. Because you have discovered abnormalities in one part, is no reason to believe that others in the same subject do not exist. It is for this reason that a thorough intra-abdominal examination should be made to discover pathological conditions or beginning pathological conditions that exist, causing trouble and discomfort without having been diagnosed previous to celiotomy.

Since we have decided that this is a surgical disease, the operation to be used is also of initial importance.

# DIAGNOSIS AND TREATMENT OF GALL BLADDER DISEASE\*

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SINCE Graham's epoch-making method of diagnosis (1924) by the intravenous injection or the imbibition of sodium tetraiodophenolphthalein little of importance of a similar nature has been brought to the notice of the profession. Various liver functional tests have been proposed and while they are not exactly of diagnostic importance, they do give us an index of the work the liver is capable of performing. Indirectly, they sometimes help in making a diagnosis, but they are especially directed to guide us in the selection of the case for a proper operative procedure.

I believe the dye test is being used universally with varying results in helping us to measure the function of the gall bladder. Before the use of this test a positive diagnosis of cholelithiasis by the use of the x-ray was about 15 per cent. Graham and his associates believe that 98 per cent of diseased gall bladders can be correctly diagnosticated. This percentage is probably a little high, but there is no question that with the introduction of the Graham test we have been better able to arrive at more logical conclusions in reference to the diseased gall bladder. Erroneous ideas concerning the function and the physical characteristics of the gall bladder occur very often as a result of the conclusions reached after reading the x-ray plate. Here, as always, we depend on the personal equation of the man reading the plate. A gall bladder which, for instance, empties itself well after the ingestion of the fat meal, does not necessarily mean a healthy gall bladder, while on the other hand, one that does not empty itself well is surely the seat of some pathological condition. This has often been substantiated at operation. Only rarely does it follow that a gall bladder that does not empty itself after the fat meal, is found at operation to be normal. Certainly all these cases must

have had symptoms, otherwise the test would not have been made. The dye test often misses stones, but it may be said in support of the test that it usually finds them. Only recently 2 cases have come under my observation where the single stone type was missed. In the one, a pure white cholesterol stone was found at operation. It was the prettiest gallstone I have ever seen and no amount of x-ray would have revealed it. In the other case, there was no excuse for not revealing the presence of the stone. Last week I operated on a case which, according to the results obtained from the dye test, should have shown very decidedly a diseased gall bladder. The test showed that the dye did enter the gall bladder well, that after the fat meal the dye was not expelled normally. We found a gall bladder, not particularly diseased, its luster somewhat dimmed, and there were no stones. We removed the gall bladder and found the cystic duct patulous.

Diagnostically, bile drainages have assumed for me an entirely new place in the separation of those cases possessing gallstones and that large class of cases that have symptoms without gallstones.

I always believed in bile drainage from the standpoint solely of helping to make a diagnosis, and have so stated on many occasions. Its curative properties always were doubted and I still adhere to that belief. Some patients are temporarily relieved of symptoms, while I have found a few who were made worse by the drainages, which at times brought on an acute attack of colic.

It is easier to diagnose cholelithiasis after a drainage than after an x-ray; it takes less trouble and it is certainly less expensive. It may be a startling statement to make when I tell you that I would rather depend on the microscopic diagnosis

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than upon the x-ray diagnosis. The former is especially helpful in those cases where the radiologist has reported no stones in the presence of all the classical symptoms. Several cases have come to operation where the radiologist has reported no stones, when the microscope revealed the presence of crystals and pigment. Their presence I consider a pathognomonic laboratory sign of cholelithiasis. While it is always better to make a diagnosis of stones on the presence of crystals alone or pigment alone, preferably the latter, one or the other has been sufficient on which to make a diagnosis. The infallibility of this laboratory test is so well known in the services of the hospitals with which I am connected, that it becomes an easy method for the interne to perform and does not require any expensive equipment. Still, I do not think it will displace the x-ray. Firstly, because patients demand this method of examination and secondly, in order to keep hospital records up-to-date, we usually request the x-ray examination. Also it makes the two examinations a fine means of comparison and a good check up, one against the other.

The Van den Bergh test is a fine method for the separation of the obstructive types of jaundice from those of the non-obstructive.

The icterus index test, while not nearly as useful as the former test, still is of interest in showing the diurnal variations of the depth of jaundice in obstruction.

It has always been foreign to my method of presenting a paper to begin the discussion with laboratory methods, since invariably I consider the history of the case of prime importance. Laboratory methods can never supplant or supersede the history that one receives from the patient. This caution must always be sounded because there is still too much dependence being placed on laboratory methods before a good history has been obtained.

One can never forget the symptoms of a patient in the midst of an attack of acute gallstone colic. The patient suffers excruciating pain of varying degrees referred to the right upper quadrant. The pain may

extend to the shoulders, right or left, usually the right. There may be severe headache, the pain radiating there instead of to the shoulders. Almost always the pain comes on at night, but it may appear at any time of the day. If the patient suffers a gallstone attack at night, characteristically the patient will be free of pain by daylight. Certainly there are many modifications of these phenomena. The patient vomits a little bile, or there may be several paroxysms lasting hours. Coupled with these symptoms a physical examination will almost always make the correct diagnosis. In gall bladder disease, tenderness and rigidity are always present in the right upper quadrant. If nephrolithiasis is present, there will be tenderness and rigidity in the lumbar region, or a little higher in the loin space. Attention to this palpatory diagnostic sign will be of great help in separating gallstone colic from that of the colic due to stone in the kidney.

It is not so easy, however, to separate the signs of an acutely inflamed high appendix from that of gallstone colic. These appendices are usually undergoing gangrene, but if perforation ensues, the pain disappears, followed by localized and later, general peritonitis.

While an acute pancreatitis may sometimes be difficult to separate from acute gall bladder colic, there ought to be very little trouble in the separation of these two. There is no affection so painful as that of acute pancreatitis. The mere fact that morphine has little or no effect ought at once to put us on our guard. General peritonitis and a board-like rigidity accompany the pain, which are the two signs that one must always remember.

A mild, fleeting attack of pancreatitis is difficult to differentiate from gallstone colic. The symptoms are the same with the possible exception that in pancreatitis there may be a slight conjunctival jaundice. Here also the microscopic drainage test is of great value in separating the two affections. At operation the diagnosis is rather easy because the pancreas is harder than normal. The hardness may not per-

vade the whole pancreas, but may affect the head, the tail, or part of its body. The appropriate treatment here is one of the drainage operations, either internal or external, preferably the former. It is rarely difficult to separate a perforated ulcer from an attack of acute gallstone colic.

General peritonitis with its board-like rigidity is never found in patients suffering from acute cholelithiasis. Hence, it is most important that we be on our guard in the separation of the symptoms of this quadrate of infections, namely, cholelithiasis, acute pancreatitis, acute perforating ulcer and acute appendicitis.

Occasionally, attacks of angina pectoris are confused with gallstone colic, but there is usually very little difficulty in distinguishing these two conditions. There is, however, a slow toxic effect on the heart as a result of a long continued infection of the gall bladder. It may present itself in the form of an extra systole or a myocardial change which may even make the operation a hazardous one. There is no question that some of the unaccountable deaths which follow a cholecystectomy may be traced to a damaged heart as a result of a chronically inflamed gall bladder. We have done a lot of work along these lines and have invariably found that the heart has been much benefited after operation. There is always a temporary remission and in some a permanent good effect.

It is impossible to go over the whole category of gall bladder infections, but I would like to refer to that most interesting symptom, jaundice. Jaundice, as a symptom, is probably the most important single sign that one can encounter in the whole realm of gall bladder disease. It may be of two kinds, obstructive or non-obstructive, known as the hemolytic type. The latter is an interesting condition and must be separated from jaundice due to stone, tumor or adhesions. The latter are especially difficult to separate when accompanied by painless jaundice without a blood picture. Painless jaundice is always found in the hemolytic type. This form may also be present in gall bladder disease and its

passage-ways, in which case we must be suspicious of some malignant condition. In hemolytic jaundice a physical examination will present an enlarged spleen, because this organ is unable to destroy the red blood corpuscles quickly enough, while in gall bladder disease the spleen is normal in size. Hemolytic jaundice is curable by means of a splenectomy and the results are most gratifying.

Obstructive jaundice gives one an entirely different condition to cure. Its causes are many, the most common being a stone in the common duct. Other causes are tumors of the pancreas, of the papilla of Vater, adhesions within or without the common duct, stones in the hepatic ducts or the small ducts of the liver, diseases of the liver and the various types of liver conditions causing pressure on the parenchyma and its bile capillaries. The surgeon and some internists and gastroenterologists are still at variance as to the proper time to operate on these cases. Some as yet believe that there is still the so-called catarrhal jaundice. This, I believe to be a fallacy, because in my opinion there is always some obstructive influence to account for the jaundice. A case in point is one on which I operated upon just a few days ago. This patient was a young man, aged thirty. He noticed about ten weeks ago that he was jaundiced; there were no other symptoms present, no pain, no discomfort or even digestive disturbances. We kept him in the hospital three weeks before we suggested operation. Drainages did no good, therapeutically speaking. At times a light-colored bile was obtained, but duodenal contents were mainly aspirated. No *B* bile was ever obtained. At operation we found a stone in the gall bladder, and in addition, a swollen head of the pancreas causing obstruction to the flow of bile through the papilla of Vater. The gall bladder was not removed, but drained as it is a rather hazardous thing to do to remove a gall bladder in the presence of jaundice. The common duct was explored and found to be free of stones. It also was drained.

It would not be profitable to discuss

with you the category of operations for the relief and cure of cases having obstruction of the common duct. At times the general practitioner asks the impossible to relieve patients of their jaundice. This was recently illustrated in two patients who had only slight jaundice following a cholecystectomy. There were symptoms of partial obstruction about every two weeks, but these were always relieved; in the one, by means of drainage with the Rehfuß tube, in the other, by the opening of an external sinus. I advised against operation in both of these cases, because they were leading a life of comparative comfort. After having visited other consulting surgeons, they were advised to undergo operation. I operated on one of these cases, the other operation being performed by the consulting surgeon. Both women were on the table for three hours. In my case the common duct was found after two hours of searching with a hypodermic needle; in the other case the common duct was not found at all. However, there are cases in which obstruction is complete, when there is no other alternative but to operate and relieve it by means of an internal or external drainage operation. I am referring now to those cases that have previously been operated upon and some disturbance follows in the common duct causing complete obstruction. One must never underestimate the dangers involved in operating on these cases, because great difficulty is encountered in finding the common duct, especially when the obstruction is due to adhesions, or injury of the common duct at or near the hepatic ducts. The longer the time consumed in the operation the greater is the danger to life.

Just one more illustration of the stamina with which patients can withstand three major operations in the space of a few weeks is worthy of record here.\* A man fifty-two years old was sent to the Mt. Sinai Hospital with symptoms of gall bladder

disease. He had been studied by eminent physicians and there was some difference of opinion among them concerning his condition. The gall bladder was removed without difficulty; in fact all marvelled at the ease with which it was removed. On the third day the patient developed jaundice; this became worse as time progressed and after four weeks from the time of the first operation we opened him again; the common duct could not be found after we had searched for an hour. We closed the wound with the knowledge that he would not be benefited by this operation, but with the firm conviction that he would be operated on again after he had recovered his balance. As predicted the jaundice did not improve; in fact he was developing symptoms that portended disaster. The abdomen was opened again three weeks after the second operation and the common duct was found in twenty minutes from the time the abdomen was opened. A tube was placed in the hepatic duct, the distal end was placed in the stomach and then the stomach was sewn down close to the duct. The jaundice disappeared rapidly. He is now making a nice recovery.

#### SUMMARY

1. The Graham test is of considerable value in helping us to diagnose diseases of the gall bladder.

2. The microscopic examination of bile obtained by the Rehfuß tube in the duodenum is of great value in detecting the presence of stones in the gall bladder. It has given 100 per cent positive results.

3. No tests, however, can supercede the taking of a careful history of the patient.

4. We must always be on the alert to differentiate gallstone colic from other acute affections of the abdomen.

5. Jaundice may be obstructive or non-obstructive, painful or painless.

6. When absolute obstruction is present, an operation must always be performed. In partial obstruction the greatest judgment must be used in operating.

\*This patient was operated upon for the fourth time by the Walton technic for reconstruction of the common duct. Bilirubin has reappeared in the stools.

# CONSIDERATION OF THE METATARSALS AND THEIR INJURY\*

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AN expression for consideration of fractures of the metatarsal bones is presented, with the hope that something upon the subject, in a broader sense than that which is ordinarily given, will be of interest to the surgeon, whose province is in the field of bone and joint surgery.

*The gross anatomy of the metatarsals* is such that we may describe these bones as a group in regard to shape and position, with relation and function much in common. All articulate proximally and distally with bones for support and joint service. Interosseous muscles and ligaments bind them snugly together into a bundle and assist toward maintaining this relation more intimately with the distal tarsals, (from within outward, the internal, the middle and the external cuneiform and the cuboid bones). Proximally the metatarsals participate only in a gliding motion upon these tarsals and their adjacent metatarsals. These bones are of the long variety, presenting a rather long and slender shaft with large proximal and small distal ends or heads. The respective shafts of all these bones are slightly bowed, the upper surface being rounded and the entire shaft arched slightly with the convexity directed upward. They taper generously from the tarsal end forward to the phalangeal end, while the narrowed surface of each metatarsal is directed downward to the plantar surface of the foot. The tarsometatarsal heads are rather flat while the metatarso-phalangeal heads are almost hemispherical. Distally the metatarsals ride freely so that the head functions as a base in the metatarso-phalangeal articulation. The uncommon anatomical features of the metatarsals are not of sufficient significance to warrant particular concern for fracture treatment.

*Mechanical Consideration of the Metatarsal Bones.* This group of bones spreads out distally from the tarsometatarsal articulations to enter in the formation of the five digits of the foot. The metatarso-phalangeal joint or the distal metatarsal articulation accomplishes all of the movements of each digit, viz.: adduction, abduction, flexion and extension. The metatarsal bones enter collectively in the entire formation of the transverse arch and in the partial formation of the longitudinal arch. It is the damage to these bones, their ligamentous or muscular attachments which, if not properly considered, lowers, relaxes or destroys either or both of these arches.

*Combined Foot Movements as Related to the Metatarsal Bones.* At this point the combined foot action, inversion and eversion must be mentioned. These come about mostly with the action of the astragalocalcaneal joint, but the ligamentous attachments to the joints anterior to it assist in completing these movements. No movement of the foot need be stressed as of value unless applied with the function of support and progression. The longitudinal and transverse arches are very important in the performance of these acts.

*Progressions.* There are several performances of foot function during walking. The movement in the first act, is raising the foot from the surface. In the second act the body-weight is rocked anterior upon the lateral and medial piers of the longitudinal arch. In the third act the weight should be relieved from the outer or lateral pier and transferred entirely to the medial pier or pod. The fourth act is accomplished as the body load is further thrown to the ball of the great toe or the distal end of the first metatarsal bone, the

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distal end of the medial pod of the longitudinal arch, which pushes the body forward as the opposite foot passes through a similar series of movements, beginning as its mate leaves the surface.

*Susceptibility to Injury and Permanent Impairment.* The metatarsal bones with their attachments are an intricate, closely related and firmly built-in bony group with muscles and many ligaments for support and movement. It is, therefore, not astonishing that these parts are frequently and readily injured. They are quite susceptible to damage which is ordinarily overlooked after the subsidence of the acute symptoms immediately following injury to the foot. Fracture-tears or fracture sprains are a common type of trauma to the foot architecture and their seriousness is not sufficiently evaluated. Possibly, more fractures go unattended in this particular location than in any other portion of the skeletal structure unless it might be the digits. Furthermore, even recognized injuries to the bones of the foot occasion a surprising lack of concern. Many patients of this sort allow a painful foot to go unattended for weeks or months. Of course, in such instances, it is not uncommon to find a fallen arch (splay-foot) or even more serious and possibly irreparable damage. Relaxation of the ligamentous structures is likely to occur with unattended fractures in this location and reconditioning of these parts consequently goes beyond the simpler methods for correction. An unreduced metatarsal fracture occasions distress and serious deformity to the foot and is more to be dreaded than a poor or vicious union.

*Causes of Fracture of the Metatarsal Bones.* Fracture of a metatarsal bone occurs either from direct or indirect violence. Probably the most susceptible and most frequent metatarsal to fracture is the fifth. It is the one which is commonly subject to individual fracture by indirect violence, such as sudden twisting or turning on the outer pier of the longitudinal arch. Direct violence, as a crush, from a weighty object

passing over the foot, or a blow from a heavy falling object, is the commonest factor for metatarsal fracture.

*Types and locations of fractures of the metatarsal group* are numerous. They may be such that one or several of these bones enter the injury. The fracture may be with or without displacement, and as either it may be simple or compound. We may have a fracture-tear, a complete or incomplete fracture, or any of the great variety of fractures to which long bones are subject. When the fracture is one without displacement, little concern about trauma to the soft parts is necessary. When, however, there is displacement, there are possibilities of complications, such as joint injury, rupture of blood vessels, nerve injury and severe destruction to the musculature. When a metatarsal fracture is not of the compound variety there is little danger from any of these complications, even though there should be considerable displacement of the fragments. In the case of a compound metatarsal fracture the most serious issue to combat is infection.

*Subjective Symptoms.* The history of some distinct foot injury will commonly be given. After such injury the foot becomes very painful and there is swelling with difficulty or inability to use same. The pain generally radiates upward into the musculature of the lower leg, peroneal muscle region, and forward to the one or several toes associated with the fractured metatarsal. In less severe cases there may be only rapid swelling and discoloration. There is aggravation of pain on motion, as during efforts to function.

*Objective Symptoms.* In the more severe cases the subjective symptoms are masked, more particularly since the patient is in a state of shock of variable severity. Great pain is elicited, when the patient's general condition is unaffected, during efforts at motion or manipulation at and about the immediate location of fracture. There is distinct point-tenderness over the fracture site. Impact by forcing the toe of a sus-

pected metatarsal toward the tarsal group elicits sharp pain. Crepitus may or may not be present. There may or may not be mobility of fragments. In preference to eliciting such symptoms, and when little doubt remains in the mind of the surgeon that there is severe injury, it would be more advisable to rely upon the evident symptoms. The x-ray should always be depended upon. It will locate, detail and confirm any fracture of the metatarsals without causing discomfort.

*Diagnosis.* Metatarsal fractures might be confused with fracture of adjacent bones, contusion or sprain. The x-ray will remove doubt about which of these conditions should be eliminated, although it is very common to find such fractures complicated with any or all of these. The allied injuries with which fracture of the metatarsal bones might become confused require the same treatment at the outset, namely, rest. In such an event the injury under observation is diagnosed by exclusion, with the further findings of symptoms, and as a last resort, with the findings of the x-ray.

*Treatment of Simple Fractures.* The sooner proper immobilization of a metatarsal fracture is instituted the better will be the end-result. Where there is no displacement it is often advisable to allow no disturbance of fragments by manipulation, because with proper splinting the part will correct itself. Little or no deformity should result in such cases so long as there is some end-to-end thrust of fragments, with full consideration being given to the factor of neutral muscle-pull. Neutral muscle-pull materially assists in bringing into normal relation properly supported bony fragments. Where there is marked displacement it is advisable to increase the deformity and then to endeavor reduction. Ordinarily, the fracture of one metatarsal produces little or no displacement and the part may be immediately placed in a plaster-of-Paris cast.

*Treatment of Compound Fractures.* Most of these fractures are of the com-

minuted and displaced variety. They are considered as infected wounds. Frequently, because of the gravity of infection or because of irreparable maceration of the soft parts and the fear of gangrene, amputation is considered early. This should not, however, be too hastily undertaken. Give the damaged tissues every encouragement for regeneration and assist them with proper antiseptic measures to overcome infection. The constitutional evidences of the patient can at all times be the guiding factor for decisions relating to removal of fragments which, it is hoped, may be spared for possible restoration to function. Doctor Fred Albee says, about any severe trauma which threatens sacrifice, "Save every fraction of an inch." It is not a bad end-result which establishes ankylosis because of infection. A deformed foot can still prove very functional and reconstructive work can always be considered with spared structures. It is better to chance the battle with a compound fracture of the metatarsals than to sacrifice promiscuously, as an early drastic procedure, crushed components of the foot. The common but not a real interference with conservatism for fullest restoration to function is time. A deformed metatarsal is better than one which is removed. In severe compound injuries always endeavor to save the traumatized structures, establish splintage of the fractured metatarsals early and remove all displaced fragments which are unattached. Convert all compound fractures to simple fractures as speedily as possible. The commonest and most serious problem to overcome in the effort will be infection and the dangers therefrom are minimized with modern antisepsis. After a compound fracture wound has been rendered clean, no matter how complicated the fracture may be, such injury merits the ordinary treatment for simple fracture, viz.: reduction of fracture, proper immobilization and aseptic surgical dressings for the open but sterile wound. Do not endeavor the reduction of a compound fracture until complications



of infection are safely overcome. Traumatization of the soft parts during efforts at reduction is not unsafe in a surgically clean area and need not imply reinfection.

*Reduction and Immobilization.* In treating all compound fractures the feature of changing dressings until the open wound is closed, should be primary. When this is accomplished the fracture becomes one of the simple variety and reduction, at even so late a time as four weeks after the accident, may be safely undertaken by the closed method. When the bony fragments of a metatarsal fracture are well approximated it is ready for immobilization, preferably in a plaster cast. Such a cast should extend from the base of the toes to about 3 in. above the maleoli. This large type of cast is advised in fracture of any of the bones of the foot, individually or collectively, barring phalanges. No dressing will accomplish the ideal immobilization of a plaster-of-Paris cast, and although splintage with some other form of support may be obtained this dressing, after closure of any wounds and final reduction of the fracture, is best. All patients should be advised to go about early upon crutches with no weight-bearing upon the injured foot. Thus, on the first day after reduction the patient is to be encouraged to go about when there are no contraindications. No metatarsal fracture should be immobilized in a cast for less than three weeks. Where the factor of compounding complicates matters the treatment of this factor becomes a separate consideration and subsequent immobilization in the cast should not be for less than three weeks beyond the period of closure of the wound. For a week after the removal of the cast the foot should be kept from supporting full body-weight. Massage with active and passive movements of the entire foot and ankle may be instituted for ten-minute periods several times on the first day following the removal of cast. Hot bathing or baking is very beneficial and during such, active movements of toes and ankle are of value. Active movement periods in time lengths

should increase with each day and fuller weight-bearing with less support from the crutches should be correspondingly encouraged. On account of the importance of the metatarsals in weight-bearing, it is ill-advised to use the foot for full body-support in less than one week after removal of cast. When several metatarsals are involved or when the tarsals enter the injury it would be well to increase the period for restoration to full function from four to five weeks. After a four-week period of complete immobilization in this type of fracture weight-bearing may be gradually increased from day to day taking more and more of the load from the crutches and placing it cautiously and gradually upon the injured extremity.

Osteogenetic formation in fracture begins most actively about four days after the injury. Calcification of the area for union is the last and slowest process in the formation of the callus. When a callused area does not calcify sufficiently the soft bony growth under strain gives to such a degree as to cause a relaxation or stretching of the ligamentous attachments. This danger must be fully appreciated before permitting the use of a foot with a freshly reduced metatarsal fracture. Complications to be expected from too early use of foot for weight-bearing, are disturbing and harmful, the impairments resulting therefrom, contributing to dysfunction.

*Case Reports.* The following cases are illustrations of some of the varieties of metatarsal fracture treated:

CASE 1. Mr. C. H. S., aged forty-seven, moving-man. Severe injury to the first metatarsal bone of the left foot, caused by a heavy piece of furniture falling across same. Became weak and sick for a short spell. After recovery continued to walk upon foot during day of accident. Pain and swelling became too severe at night following injury to allow him to go on without attention. On the following day x-ray disclosed a fracture of the first metatarsal bone at the articulation of the internal cuneiform with the first metatarsal bone. (Fracture by direct violence; intra-articular, simple non-displaced variety.)

CASE II. Mr. J. F. G., aged fifty, miner. Old compound comminuted fracture caused by a dinky-car passing over foot. X-ray disclosed fractures of the scaphoid, middle and external cuneiform, first and second metatarsal bones, the latter two at their proximal ends, left foot. (Fracture by direct violence; old crushed type which was the result of a compound, comminuted impacted variety with displacement.)

CASE III. Mrs. F., aged fifty-two, short stalky woman. Made sudden turn on foot in effort to get away from rapidly approaching automobile. Felt a severe pain and keeled over in a faint. X-ray disclosed a transverse fracture about middle of shaft of fifth metatarsal, left foot. (Fracture by indirect violence; transverse and without displacement type.)

CASE IV. Mr. M. U., aged forty-two, laborer. Piece of heavy casting fell on right foot. Patient became sick and faint immediately following accident. Severe pain over inner side of foot and rapid swelling with discoloration because patient walked to office using foot after reaction from faint. X-ray disclosed longitudinal fracture of first metatarsal bone, right foot. (Fracture by direct violence; variety simple, longitudinal with non-displacement.)

CASE V. Mr. S. L., aged forty-two, laborer. Piece of heavy lumber fell across left foot. Became faint and was carried to his home near place of accident. Severe pain, inability to step on toes in effort to walk. Suspicion of fracture of tarsal and metatarsal bones on inner side of left foot. X-ray disclosed impacted fractures of the external and middle cuneiform with fractures of the articular surfaces of the third and fourth metatarsals (tarsometatarsal articulation). (Fracture by direct violence; variety simple, impacted, multiple and dentate with non-displacement.)

CASE VI. Mrs. P. E. B., aged twenty-four. Turned on right ankle falling down stairs. Experienced a sudden sharp pain and snap. Became sick and vomited upon removal to offices for attention. Prompt swelling thereafter on dorsum of foot. Pain on motion and during palpation, especially marked on the outer margin of right foot. X-ray disclosed fracture of the fifth metatarsal bone at its proximal end, inferior surface of the tuberosity. (Fracture by indirect violence; variety simple, incomplete, dentate with non-displacement.)

*Conclusion.* Immobilize foot in plaster-of-Paris cast for all metatarsal fractures for no less than three weeks. Use foot for full weight-bearing guardedly, beginning with the end of the third week in single and simple metatarsal fractures. Use foot for full weight-bearing guardedly after the fourth week in complicated fractures, however, only after immobilization in plaster cast for four weeks has been carried out, following completion of treatment of the compound fractures. Upon removal of the fixation cast begin prompt massage and movements with hot baths or bakings of foot each day. Crushed metatarsal fractures, although they may frequently demand amputation, may be, in instances of perseverance, spared for subsequent reconstruction work. Thus, there is afforded a better means for establishing a useful supporting extremity. A deformed foot is better than no foot, and reconstruction work affords the opportunity toward making an unsatisfactory initial piece of conservative surgery more satisfactory.



# CASE REPORT

## COMPLETE DISLOCATION OF KNEE\*

EDGAR W. WEIGEL, M.D.

PLAINFIELD, N. J.

THE patient, an auto-mechanic, nineteen years of age, while playing football was tackled from the back and fell; upon crutches or cane. Three months after the accident he was back at work, doing a heavier and harder kind of work than before the



FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

arising, he noted pain in the left knee and marked deformity of the knee. He was brought to the hospital immediately, where clinical examination revealed an anteroposterior complete dislocation of the knee, with 3 in. of over-riding of the femur behind the tibia, accompanied by marked swelling and tenderness. Roentgenograms were taken and showed the condition, with no fracture present.

One hour after the injury, under gas anesthesia, with considerable difficulty owing to the over-riding, the dislocation was reduced by traction in hyperextension. A well-padded plaster leg bandage was applied, with the knee in full extension. The knee was immobilized for five weeks, the plaster bandage being bivalved at the end of the second week to facilitate treatment with baking and massage. Six weeks after the injury the patient was bearing weight on the extremity, and eight weeks after the injury he was walking without

injury, with a pain free knee that was as stable as the other, and with a range of motion that was so nearly complete that only instruments of precision could reveal any difference from the other knee.

### DISCUSSION

DR. REGINALD SAYRE: Some two years ago I saw a somewhat similar case of a man who fell through the skylight thinking he was dropping into his own room but instead fell two stories down the stairs dislocating his knee in an almost identical manner as Dr. Weigel's patient. He was taken to Bellevue where Dr. Wadhams snapped the knee into perfect alignment, under ether, and applied a plaster of Paris splint. Four weeks later I applied a Campbell splint to prevent undue lateral mobility while he was walking around. This splint he wore for about a year, doing exercises in the meantime to develop his thigh muscles.

\* Read before the Section of Orthopedic Surgery, New York Academy of Medicine, April 19, 1929.

He now has a perfectly practical leg which he can use in driving a car.

**DR. GEORGE E. BENNETT:** This case illustrates a noteworthy point in that you can have a rupture of the anterior crucial ligament and yet have a perfectly good knee joint as the result, provided the other ligaments are intact. There has been too much stress laid upon the importance of crucial ligaments in stabilizing a knee joint. I do not think they are so important as has been thought.

**DR. ARMITAGE WHITMAN:** I should like to reinforce Dr. Bennett's remarks by the account of a case I had with rupture of both crucial ligaments, in which I did a fascial transplantation and got, as far as the crucial ligaments were concerned, a very good result. Unfortunately the patient was an extremely timid sort of person who was so afraid to move his knee that his quadriceps had gone all to pieces. This boy had a very good joint and with a good quadriceps muscle the result would have been perfect. I am inclined to think that with a good quadriceps the importance of the crucial ligaments can be minimized and if we emphasize keeping up the muscular tone of the quadriceps the injury to the crucial ligaments may not be so important as we think.

**DR. L. T. LEWALD:** In questions of knee joint injuries, Sir Robert Jones has always said that one should look for fracture of the spines of the tibia. Here is a case, however, where the knee joint has suffered the most extreme injury short of avulsion of the leg, and yet there is no evidence of injury to the spines of the tibia.

**DR. E. W. WEIGEL:** We thought that if the crucial ligaments were torn the most likely place would be the attachment to the tibial spine. I don't understand how he could have such a displacement without their being torn. The stability of the knee joint is undoubtedly due to the strength of the musculature.

**DR. KRIDA:** Fresh cases, are never, to my mind, suitable for open operation. I have seen several of these, though not so extreme as this. It is a very brilliant case, but I am convinced that the rôle of the crucial in favorable cases is not so important as in the typical injuries, those in which the internal lateral ligament is first torn and then, if the distorting force be continued there results a tear of the anterior

or both ligaments. Such a knee as I have described may have as a late result a general instability of the knee joint. This, so far as I



FIG. 5.

FIG. 6.

know is not reparable except by repairing the crucial ligament or by inducing ankylosis.

**DR. CHARLTON WALLACE:** I had two patients: one was a jockey who was thrown from a horse. The base of both spines of the tibia was torn off and the crucial ligament along with it. There was considerable fluid in the joint, which was evacuated and treated conservatively, and he made a perfectly good recovery. The other case was that of a man who stepped down a three-foot trench in the dark and ruptured both crucial ligaments. He was treated conservatively with the idea of developing the muscles going down to the leg; if their tone was restored he would get a good functional result, which he did.

**DR. ELMER P. WEIGEL:** It must be that the crucial ligaments at the time of injury were severed and the reason he has such a good knee now is due to his good musculature. I cannot conceive of the ligaments being stretched to that extent without more serious results.



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## EDITORIALS

### NEEDED—AN ANESTHESIA FOUNDATION

AMERICA is the birthplace of anesthesia; to her belongs the honor and esteem of having made the first discoveries and the public proofs of its wonderful and far-reaching possibilities; world-wide acclaim was ours for bestowing upon suffering mankind this most beneficent and almost priceless boon whereby remedial surgical procedures could be performed without causing the patient pain. The announcements of the early clinics demonstrating surgical anesthesia awoke among the medical profession of the world an enthusiasm for scientific research which can be paralleled only by the published reports of a Pasteur, a Curie, a Roentgen, or a Banting of more modern times.

Yet, strange to relate, it is a rather sad commentary that there does not exist in the United States today a single School or

Foundation, backed by a real, live, scientific research department, where all the different exemplifications of the anesthetic art are used and taught. Nor is there a proper correlation of ideas concerning the many methods of anesthesia. True it is that one may go to this or that hospital to learn inhalation anesthesia by ether or gas-oxygen, or their combinations; yet, to acquire a knowledge of rectal and intravenous anesthesia, it usually is necessary to go somewhere else; and, to see spinal anesthesia and regional anesthesia demonstrated, again one must visit still other clinics.

Further, there are those who claim that inhalation is the *only* type of anesthesia which should be used, condemning regional and spinal, or other methods. Again, some surgeons and anesthetists will argue that

inhalation anesthesia is entirely passé. And so the turmoil rages, not only regarding anesthetic agents and methods, but also concerning apparatus, paraphernalia, equipment and other allied factors. Nowhere in the United States today is there an outstanding Anesthesia Foundation of such preponderant prestige and such broad-mindedness, *backed by a painstakingly thorough department of research and publicity*, that to it could be referred for solution both the old and the new problems of anesthesia, and from it could come the most trustworthy and unbiased information and judgment.

It is not difficult for even the laity to comprehend the pain and suffering attendant on the inadequate and oftentimes indifferent surgery which was performable in the pre-anesthetic era; yet, it is believed, many surgeons of today fail properly to recognize that largely because of the varied and manifold advances in the anesthetic art has it been possible for surgery to have made the brilliant progress of recent years, all for the common good, for humanity.

As with many things accepted today as commonplace, as having existed always, anesthesia began in a small way and with a relatively few agents, to blossom forth and fructify into a manifold and ingenious multiplicity of methods, ever keeping step with surgical progress, stride for stride. Too frequently the name anesthetist has been applied to those who understand how to administer but one or two agents and, consequently, every patient and surgical condition were forced to conform to that one type of anesthesia. This is as much in error as trying to fit every individual with the same style or size of clothes, and it is not necessary to visit many clinics to be convinced of the fact that lack of experience in *all* anesthetics often leads to faulty judgment in the attempting to attune *all* surgery to but *one* anesthetic.

Only for the sake of emphasis is it well to review that Dr. Crawford W. Long first used ether in 1842, that Dr. Horace Wells administered nitrous oxide gas to his

patients for extractions in 1844, and that Dr. William T. Morton gave the premier demonstrations of ether anesthesia in the Massachusetts General Hospital on October 16, 1846. Since that time a host of agents and methods have proved their worth: by inhalation, ether, chloroform, ethyl chloride, nitrous oxide, ethylene and carbon dioxide; for local and topical application, cocaine, procaine, butin and others; for intravenous injection, sodium amytal; for rectal injection, ether-oil, avertin, and ether-barbital; for regional, procaine and neocaine; for spinal or sub-arachnoid block, neocaine, novocaine, spinocaine, gravocaine and others. The anesthetist of tomorrow must be proficient with all agents and methods; he must be able to select and adapt each to the individual patient and the particular surgical requirement; this for but one end, that the patient may get well.

Anesthesia as a specialty, in the past, has not attracted its just proportion of the best-trained medical minds; and, in consequence, a sort of medical football, it has been kicked about, often exploited alike by surgeons, hospitals and clinics, all of whom assigned to anesthesia the most minor of rôles, in many cases relegating the work to students, orderlies and nurses, none of whom ever is permitted to administer a single hypodermic of morphine without a physician's express prescription; yet, to them often was handed a mask, with ether can or chloroform flask, and they were told to "just go ahead." This is not, never was and never can be, to the best interests of public weal; and, to overcome and improve just such a situation, to project oneself into the future ten, fifteen or twenty years, to do the real thing for anesthesia in a proper and highly scientific way, to provide the needed increase in trained medical personnel and to give them the necessary foundation, it must be obvious that a parent body, a fountain-head, an Anesthesia Foundation, is a very pertinent, present-day need.

A tentative outline of such a foundation

is herewith submitted. It does homage to those pioneers whose courage of conviction was responsible for the development of the

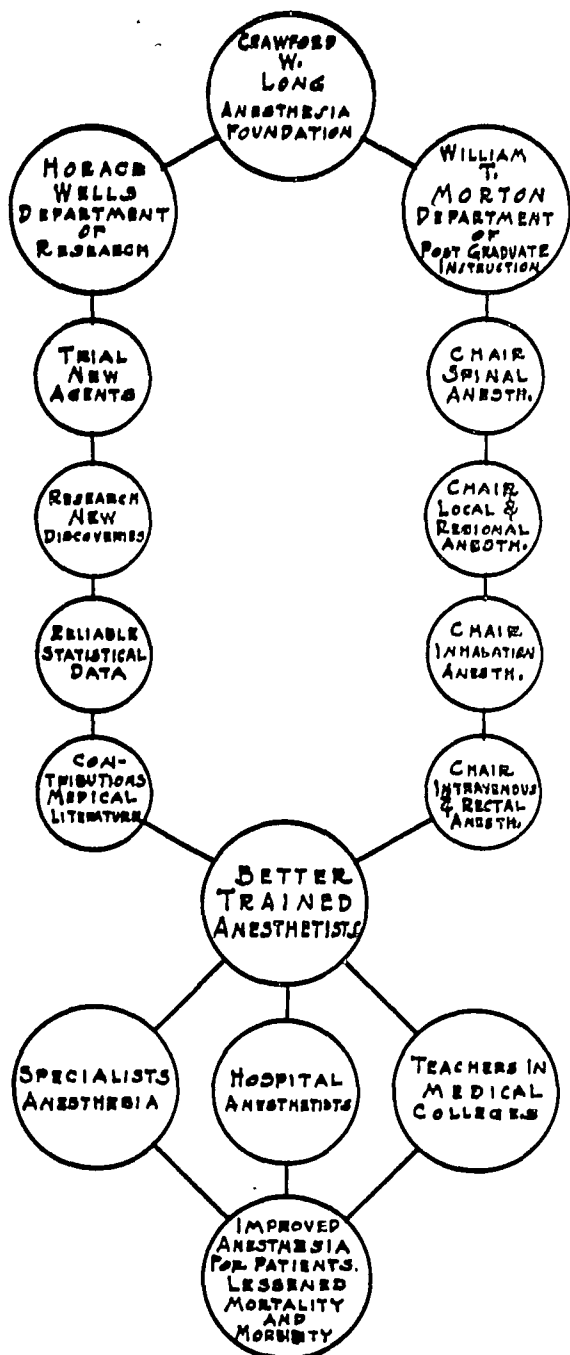


FIG. 1.

art. No living name should be attached, for apparent reasons; yet its various chairs provide a future place for men now amongst us whose work and research are worthy of acclaim. The ideals of such a foundation

should be large, broad; they must transcend even the immediate years. The foundation must be above jealousies and intrigues; its policies must be shaped toward the greatest good for the greatest number; it must be cooperative in every sense of the word with individual research workers everywhere and encourage them; it must be favored and upheld by manufacturers of medical supplies and appliances; it must be backed by a large medical center for clinical material; it must be supported by the medical periodicals; it must have the sympathetic interest of the medical colleges, for it should furnish them with their future teachers. The diagram is practically self-explanatory, excepting those details which are too numerous to include in a preliminary monograph; yet, to mention but a single angle, think of the enrichment of the medical literature, for future generations, which such a foundation would provide?

A dream? Perhaps. A utopia? No! It *can* and *must* be accomplished. The practice of medicine is an ever-progressing science; he who stands upon the right of way of the onrushing train of advancement is likely to be found among the wreckage and debris by the wayside.

Certainly, all this cannot be done in a day, a week or a year; the foundation would be just the beginning of an influence which could and should make itself felt through succeeding generations. The beginning necessarily must be small, but the results are none the less sure; the acorn develops into a sturdy oak under proper environmental influences.

How can this be accomplished? By endowment. The foundation could be made entirely self-supporting; but, for the largest good to the greatest number in the shortest period of time, ample endowment is the surest way. What an opportunity for a city! For a medical center! For an individual! It is hoped that this only too brief presentation may meet a kindly eye, an understanding mind and a sympathetic heart.

FLOYD T. ROMBERGER.

## NEW METHODS OF PRODUCING GENERAL ANESTHESIA

A DISTINGUISHED surgeon was recently heard to express the opinion that anesthetic agents of the past caused pathological effects, not in the process of producing anesthesia, but while being absorbed and eliminated. He cited the liver damage caused in the detoxification of chloroform; the lung damage accompanying ether when inhaled; and the rectal irritation resulting from colonic ether. He then went on to imply that future developments in the art of anesthesia lay in the direct introduction of the anesthetic agent into the blood stream.

To a practical anesthetist, this rather fundamental suggestion from a surgical authority proved to be food for thought. The first reaction was one of curiosity as to whether the direct introduction of anesthetic agents into the blood stream by intravenous injection was particularly new. A visit to the library brought forth the following facts. Pirogoff reported, in 1847, a series of cases anesthetized by the insufflation of ether vapor into the rectum. Intravenous ether anesthesia was extensively used by Burkhardt and others previous to 1910. In 1872, Oré reported 51 patients anesthetized by the intravenous administration of trichloroacetaldehyde (chloral hydrate) and this drug has been extensively used to produce both sedation and anesthesia when administered by rectum, the latter chiefly by Sternimann who, in 1929, advocated its routine use for producing anesthesia in infants. Previous to 1910, Burkhardt reported considerable clinical experience with the intravenous administration of trichloroisopropyl alcohol (isopral). He used this drug alone to produce anesthesia, and more extensively as a preliminary to the intravenous administration of ether. Mertens used trichloroisopropyl alcohol for rectal instillation usually followed by an anesthetic given by inhalations. In the early years of the present century, Schmedeberg, and later Dreser, did some excellent investigation

of alcohol derivatives, and produced and used, clinically, methyl-propyl-carbonyl urethane, an ester of carbamic acid (hedonal). Hedonal was used in England and on the continent to produce anesthesia by intravenous administration as well as by rectal instillation. An extensive laboratory investigation of this drug with favorable report was made by Donald.

Doubtless, the advent of the World War placed a damper on basic research in the development of new drugs in Europe. Since the war, further work on alcohol derivatives has resulted in at least one distinct advance, namely, the production of tribromethanol (avertin) by Willstätter and Duisberg. This drug has received a very extensive clinical application during the past few years. It has been administered both intravenously and by rectum to a very large number of clinical cases and the literature contains many glowing reports of its usefulness.

Marin, in 1929, reported 250 cases anesthetized by means of 96 per cent ethyl alcohol in glucose administered intravenously.

We thus see that the attempt to produce anesthesia by the introduction of drugs through the rectal mucosa or through the wall of a vein, is decidedly not new. Probably the lack of permanent enthusiasm for these methods is caused by an inherent fault in the methods themselves. The production of surgical anesthesia involves so close an approach to an interference with vital functions that the method involved should, to be absolutely safe, carry with it a control approaching instantaneous. A drug which can be introduced into the circulation and removed therefrom in a few seconds will always have an appeal to the conservative anesthetist. The use of methods which lack this quality of quick control should probably be confined to a basic preparation for the use of other methods. At the present time, the possibility of the pharmacologists' producing new drugs, which can



be administered in a previously guessed dosage sufficient to accomplish safely complete surgical anesthesia, is very remote.

If a practical anesthetist may be permitted the liberty of suggesting to the experimental chemist and pharmacologist where his future efforts seem likely to be of benefit in anesthesia, it might be stated that further work on derivatives of the alcohols, particularly halogen substitutions with the alcohols, seems to offer the brightest outlook. No barbituric acid derivative has yet been produced which seems to have primarily an anesthetic effect. Many of them produce excellent psychic sedation and are very useful for the production of sleep but in no case has a derivative of barbituric acid been found to be primarily an anesthetic agent. Overdosage, of course, produces a condition simulating anesthesia during which surgical operations can be performed, but the use of such dosage is decidedly unjust from the standpoint of safety. On the other hand, many if not most of the anesthetic agents which we now possess are either direct or indirect derivatives of the alcohols.

The greatest need at the present time in the field of general anesthesia is the development of a highly volatile or gaseous substance which will have the labile qualities of nitrous oxide gas with sufficient potency to produce complete relaxation of the abdominal muscles with quick recovery of muscular tone and consciousness when the administration is interrupted. Investigation is being conducted along this line by V. E. Henderson. Such a drug to be used in conjunction with the drugs now available, or to be made available, for intravenous, subcutaneous or rectal administration might approach the ideal.

What can the practical anesthetist in the operating room find of additional value in the newer drugs and methods offered for the production of anesthesia? He will doubtless find a field of usefulness for barbituric acid derivatives in the produc-

tion of sleep to accompany block anesthesia by means of procaine or its substitutes, and to prepare the apprehensive patient for inhalation anesthesia. He will doubtless wish to choose a barbiturate with a short-lasting effect rather than one which maintains sleep over long periods. A drug which promises something along this line is secondary butyl-brom-allyl barbiturate (pernocton). Ethyl-methyl-butyl barbiturate also gives promise of early detoxification and reasonable stability of dosage. He will doubtless find the rectal administration of tribromethanol advantageous in certain types of cases. The instillation of a bland solution into the rectum to produce sleep in children is highly desirable. Certain individuals, on the other hand, would much prefer an intravenous injection to a rectal instillation. There is little to choose between a barbituric acid derivative and tri-brom-ethanol as inducers of sleep. A quick pleasant "dropping off" is the result.

The anesthetist should bear in mind that new drugs will undoubtedly be produced which are more desirable than those now available, but he should also remember that careful laboratory and animal experimentation must precede their clinical trial. At no time should the fact be lost sight of that the dosage of anesthetic drugs is extremely variable for different individuals, and that a predetermined dose based on body weight, age or any other known factors, is seldom reliable. Particularly is this true of barbituric acid derivatives. Physical signs, alone, can determine the effect of anesthetic drugs. Any drug, therefore, that is administered by rectum or intravenously must be given in dosage short of that necessary to produce complete, deep surgical anesthesia. Completion of surgical anesthesia should be effected by the use of a drug controllable from second to second as the exigencies of the case demand.

RALPH M. WATERS.



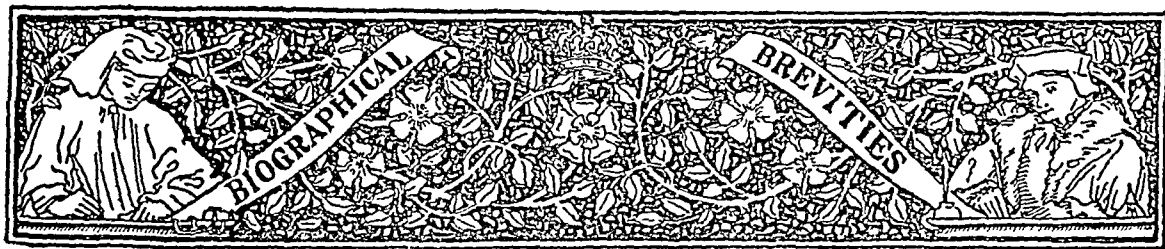




*Henle*

JACOB HENLE

[1809-1885]



## “THE HENLE TUBULES”

JACOB HENLE was born of Jewish parents at Fürth, near Nuremberg, in 1809. He died, having reached a high pinnacle in science, at the ripe age of seventy-six years.

He was a great anatomist and the foremost German histologist of his day.

He began his scientific life as one of Johannes Müller's most brilliant and favorite pupils. Henle was one of his prosectors at Berlin. Later he was professor of anatomy at Zürich (1840), Heidelberg (1844), and Göttingen from 1852 until his death.

Henle's life was a many-sided one and into his years he crammed the accomplishments of several normal existences.

He was the founder of our present conception of the epithelial tissues of the body.<sup>1</sup>

In his “Allgemeine Anatomie”<sup>2</sup> Henle demonstrated the presence of smooth muscle in the middle coat of the smaller arteries. This was the beginning of the present theory of the vasomotor mechanism. In addition, he discovered the external sphincter (striated muscle) of the bladder, the central chylous vessels, the internal rootsheath of the hair, the Henle tubules in the kidney (1862, contained in his “Handbuch der systematischen Anatomie”), gave the first accurate description of the histology of the cornea, and described the morphology and development of the larynx. Henle was the first to demonstrate many important structures of the brain.

During 1838 to 1841 Henle collaborated

with Müller in his monograph on the plagiostomes.

He wrote an essay “On Miasms and Contagia” (1840) which contains the first clear statement of the idea of a *contagium animatum*. He elaborated Müller's belief that fever is only a symptom. In his “Handbuch der rationellen Pathologie” (1846-53) he claimed it to be the physician's duty to prevent and cure disease; that all disease is a deviation from normal physiologic processes, and that death is the cessation of metabolism. In 1844 he discovered cylindric casts in the urine.

Henle wrote two books on anatomy. The first, “Allgemeine Anatomie” (1841), was the first treatise on microscopic histology. It contains the simplest and best classification ever made. Later (1866-71) he brought out “Handbook of Systematic Anatomy,” a three volume affair, very thorough and highly scientific. Henle did the illustrations for it and said that they are architectural rather than diagrammatic.

Henle was a pleasing and engaging lecturer. As he instructed his students he illustrated his points with clever drawings on a blackboard.

For avocations he dabbled at art, was more than a mediocre poet, and was an accomplished musician, playing several instruments. His first marriage was unusually romantic and seems foreign to the part of a German scientist.

Henle's friendships were many and with the first minds of his time. All in all his life was almost the ideal so many dream of but so few attain. In the midst of his many interests, Henle, an old man, departed from this life in 1885.

<sup>1</sup> Symbolae ad anatomiam villorum intestinalium imprimis eorum apithelii et vasorum lacteorum. Berlin, 1837.

<sup>2</sup> Leipzig, 1844.



[From Fernelius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

FLORENCE NIGHTINGALE

ANGEL OF MERCY AND HUMAN DYNAMO\*

FRANK K. BOLAND, M.D.

ATLANTA, GA.

FEW speakers at the graduation exercises of nurses' training schools fail to refer to Florence Nightingale, but fewer still give the audience facts about her life and work. The average citizen perhaps knows that she was some kind of a nurse, but not many appreciate the tremendous influence which she has wielded upon the art and science of medicine. It is a welcome obligation placed upon the medical profession to perpetuate her memory, and in this day of belittling biographies to preserve the truth concerning her achievements.

In reviewing her career one is at once struck by the fact that for the sake of humanity and for no personal gain, she voluntarily forsook a life of pleasure and ease to plunge into a whirlpool of hardships and responsibilities which few of either sex could have withstood. She turned her back on wifedom and motherhood, woman's supreme sacrifice.

She was born of English parents in Florence, Italy, in 1820, and lived to be ninety years of age, dying at her home in London, in 1910. She was named Florence after the city in which she happened to be born. Her father's name originally was Shore, but following an English custom,

he adopted the name of his wife's uncle, Nightingale, when she inherited his large estate. The acquisition of this fortune enabled Miss Nightingale in later life to put into effect measures which otherwise might have failed. When she needed money for feeding and clothing soldiers, and was unable to obtain all that was necessary from the government, she contributed from her own resources.

She had the advantage of the best education of the day, and certainly possessed more than appears in the college girl of the twentieth century. Not only was she well versed in the classics, but she knew the science of the times. When she entered the Institute of Protestant Deaconesses at Kaiserwerth, Germany, in 1850, for a few months' training in nursing, she already had studied anatomy and physiology. One distinguished gentleman, next to whom she sat at dinner, remarked that he considered her a capital young lady until she floored him with her Latin and Greek.

Florence Nightingale did not care to be a teacher or devote her life to literature; instead she always was interested in the sick and distressed, and felt a call to help them. For a woman of her high social position, or for any kind of decent woman

\* Submitted for publication June 16, 1930.

to become a nurse in England eighty years ago, was an unheard-of thing, and required profound conviction and courageous deter-

mination. Thereafter military hospitals were converted from bedlams of filth and misery to havens of efficiency and comfort, with



FLORENCE NIGHTINGALE

mination. The bulk of nursing in those days was turned over to an inferior class of women generally without training or character, though the modest school at Kaiserswerth was in existence, and Catholic orders gave instruction in the care of the sick, not as a calling, but as part of their religion. Miss Nightingale's first experience was as superintendent of an "Establishment for Gentlewomen during Illness."

The Crimean War in 1854 furnished her the opportunity to render to sick and wounded soldiers service which has become

the result that soldiers were able to return to duty with the least possible loss of time. This war was fought between Russia on one side, and England, Turkey and other allies on the other side, Crimea being a peninsula in the Black Sea, between Russia and Turkey.

After the battle of Alma, startling stories came back to England as to the horrible state of affairs in the great Barracks Hospital at Scutari, Turkey, so graphically described by Lytton Strachey. The building was overcrowded, and was so old and worn that it was impossible to clean it.

Apparently no preparation had been made for the care of patients. There was little ventilation and less plumbing. The beds were mostly of straw, and many were laid directly upon the floor. The few sheets to be had were of rough canvas, and the men preferred to lie between blankets. There was no hospital clothing, and most of the patients were still in their uniforms, stiff with blood, and often covered with pus and vermin. The food was badly or half cooked, and the very ill patients had nothing they could eat. Cholera and contagious fevers were common. More soldiers died of disease than of wounds, the total death rate being 42 per cent.

The Crimean War taught the nations that soldier patients are entitled to the same treatment as civilians at home, if not better, and Florence Nightingale was the instructress. Sidney Herbert, Secretary at War, one of her closest friends, requested her to gather nurses and supplies and go to Scutari. At the same time she asked permission to do so. Their letters crossed. Thus armed with authority from the English War Office, she reached the scene with her equipment, and there bitterly opposed by military and medical heads, through her sagacity, tact and indefatigable labor, finally she overthrew the old regime, and instituted common sense and merciful methods of handling patients, the result being that the mortality dropped to 2 per cent. Such is the record, but one difficult to understand when we remember that the science of bacteriology had not yet been born. So much more glory for Florence, one of the world's greatest sanitarians. Sir Edward Cook, one of her principal biographers, said that when Florence Nightingale was born a woman, England lost a great commander. She certainly commanded the situation during the Crimean War, and produced results which probably only a woman could have done. What other name has descended to us from this conflict?

The period of the Crimean War was the most dramatic part of Miss Nightingale's

long life, and her fame rests chiefly on her epochal achievements at that time. She was then thirty-four years old, and keyed up to the highest pitch of mental and physical energy, but the exposure and strain which she suffered undermined her constitution to such an extent that she was destined the rest of her days for invalidism or semi-invalidism. The exact diagnosis of her trouble has not been given. By some it was called heart disease, by others it was termed neurasthenia. Neither condition, however, could dampen her enthusiasm nor diminish her enormous capacity for work, so that for forty more years she strove effectively, often from a sick bed, for the advancement of hospitals and nursing, both in military and civil life.

She founded modern nursing, as we know it today. She elevated from disrepute what was regarded as a lowly occupation, and made of it one of the most useful and noble of callings. Following her return from Scutari she was the popular idol of England, although she shrank from publicity. A fund of a quarter of million dollars was raised to establish the Florence Nightingale Training School, where scientific nursing was first taught. From this institution her pupils went out to teach the world. She was guilty of one error of omission, in common with many of the older surgeons who were her contemporaries. She failed to accept the germ theory, and did not include surgical antisepsis in her instruction, although she must have witnessed the triumph of Lister's great discovery.

To Miss Nightingale belongs not only the honor of creating a new profession, but also she should be credited with being the first to enunciate the fundamental principles of nursing. These we find proclaimed in her delightful though diminutive "Notes on Nursing." Here we are impressed for the first time with the importance of ventilating a sick-room and keeping it clean and warm. The proper preparation and serving of food are described, and the necessity for quiet is emphasized. Don't

surprise the patient; nothing should ever surprise the patient except a burglar. Don't sit on the patient's bed. Don't awake the patient suddenly out of a sound sleep. Don't compel the patient to crane her neck to see you when you are talking to her. These and many other commonplace rules have guided nurses ever since Florence Nightingale first put them into writing. "Notes on Nursing" is a treasure-house for all those who are entrusted with the care of the sick.

Of the numerous poems dedicated to this genius, Longfellow's "Santa Filomena" perhaps is the best known. Beautifully he writes:

Lo, in that house of misery,  
A lady with a lamp I see  
Pass through the glimmering gloom,  
And pass from room to room.  
And slow, as in a dream of bliss,  
The speechless sufferer turns to kiss  
Her shadow as it falls  
Upon the darkening walls.

Not always did Florence fill the gentle picture suggested by these lines. How could she when she subdued the stern colonels at Scutari, so amazed by her pre-

sumption? How could she be mild when in later years she coped so successfully with the leading politicians of the day? With her culture and refinement she could be as sympathetic and charming as the best. Sympathy for suffering mankind was the basis of all her efforts. To carry out her exalted plans, however, demanded driving power, often felt by her friends almost to the breaking point. To overcome obstacles her methods at times might today be characterized as "hard-boiled." Rare executive ability and keen knowledge of human nature were two of her greatest assets. She had vision in advance of the age, and lived to see most of her dreams come true. The world of medicine and all humanity must ever pay homage to Florence Nightingale.

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## BOOK REVIEWS

CREED OF A BIOLOGIST. By Aldred Scott Warthin, M.D., 60 pp., N. Y., Paul B. Hoeber, Inc., 1930.

It is refreshing to read the philosophical convictions and beliefs of one who has attained unusual success and eminence in more than one field of endeavor. Dr. Warthin is known as an exceptional teacher. He is recognized as one of the foremost pathologists of this day and age.

And so, after years of teaching undergraduates, moulding their minds and characters, after decades of delving into the deeper recesses of medical lore, after the widest kind of clinical contact with suffering humanity, this student and lover of the arts and mankind, has translated the convictions resting in his soul for others to read, ponder, and digest.

In this age of extremes when it is customary for pseudo-scholars to go off half-cocked and lay down a dogma built on false premises, it comes to one as a breath of cooling fresh air at the close of a hot, sultry day to read, and read again and again, the pages of this small book. You may not agree with the writer of the pages. But you will be stimulated and it may help you, as it is sure to help many others, to reason out your own philosophy.

It is one of the true books, a book every physician should read many times and digest, a book that comes to one's attention only at very long intervals of time.

PHYSIOLOGY AND BIOCHEMISTRY IN MODERN MEDICINE. By J. J. R. Macleod, M.B., LL.D., D.SC., F.R.S. Assist. by Roy G.



Pearce, A. C. Redfield, N. B. Taylor, J. M. D. OLMSTED and by others. Ed. 6. 1107 pp., 295 illus., including 9 plates in colors. St. Louis, C. V. Mosby Co., 1930.

This book which was first published in 1918 and now appears in its sixth edition, has definitely taken its place as one of the classics of medical literature. As the author points out, "Steady increase in general knowledge, rather than discovery, has been the feature of the advances in physiology during the past three years." It has been well stated that to know modern physiology is to know medicine and surgery and if this be true then there is no better volume to have on hand for reference than this work of Macleod's.

**GREAT PAINTERS AND THEIR WORKS** As Seen By A Doctor. A series of monographs ed. by Dr. J. G. De Lint. 1. Rembrandt. Dr. J. G. De Lint. 113 pp., 64 illus., The Hague, J. Philip Kruseman.

This book presents a new viewpoint. It is the first of a series, the purpose of which, according to the author, is "to analyse works of the Dutch painters of the 17th and 18th centuries and to notice what they contain of medical interest." This volume is divided into eleven chapters with such titles as Physicians and Quacks, Portraits of Physicians, Anatomy, Internal Medicine, Miraculous Healings, Surgery, Ophthalmology, Lying-in Room and Care of Infants, and it is illustrated with sixty-four splendid reproductions of the artist's paintings and etchings. Such a study of the work of these artists cannot but be a great addition to the cultural side of medicine. Garrison and others have previously pointed out the value, from a historical medical point of view, of the observations made by the old masters and to have a thorough study on this subject made by a scholar like Dr. De Lint is an event to be welcomed by those interested in Medical History.

**A SYNOPSIS OF SURGERY.** By Ernest W. Hey Groves, M.S., M.D., B.S.C. (Lond.), F.R.C.S. (Eng.), Ed. 9, 674 pp., Illus. N. Y., Wm. Wood & Co., 1930.

Nine editions and twelve printings since 1908 are evidence that this book has stood the test of time. Thoroughly practical, well

done and arranged for quick reference, the work belongs on the five foot book shelf of every surgeon. This edition has been largely rewritten and brought up to date. As evidence of the thorough presentation of the subjects treated the preliminary paragraph on spinal anaesthesia may be quoted: "Although the scope of this method is not nearly so great as it promised to be on its introduction, it has undoubtedly a most valuable place among anesthetics. It is impossible, however, yet to decide what is its mortality compared with general anesthesia, because: (a) many thousands of cases are necessary for comparison; (b) spinal anesthesia, in this country at any rate, is limited to cases of special gravity, whilst general anaesthesia is used for all trivial operations. Hence, what follows must be accepted with the limitations here suggested."

**COLLECTED PAPERS OF THE MAYO CLINIC AND THE MAYO FOUNDATION.** Ed. by Mrs. M. H. Mellish, Richard M. Hewitt, B.A., M.A., M.D., and Mildred A. Felker, B.S., Vol. XXI, 1929. 1200 pp., 279 illus., Phila., W. B. Saunders Co., 1930.

The editor states that for this volume "There were 471 papers from which to make selections. Of these, ninety are reprinted in full, twenty-three are abridged, sixty-eight are abstracted, and to 290 references only are given." When it is realized that the 1200 pages represent only a small portion of the work done at this clinic in one year, an idea may be obtained of the tremendous amount of work turned out at Rochester. The editing, as always, is well done and this volume like the previous ones in the series is a distinctive contribution to surgical literature.

**SURGICAL DIAGNOSIS.** Vols. I, II, III, and Index. By American Authors. Ed. by Evarts Ambrose Graham, A.B., M.D., 2907 pp., 1250 illus., Phila., W. B. Saunders Co., 1930.

The Editor states that: "In preparing this work on Surgical Diagnosis an effort has been made to construct a book which will be helpful not only to the surgeon but to his medical colleagues as well." It is to be hoped that many medical men will read this work.

The subjects are treated completely and without padding. The illustrations, which are numerous and useful, have been well selected. The contributors include the leading men of the day. It is interesting to note in comparing this new system with the older ones, the large number of new men who have been developed during the last generation and who have made a name for themselves in their respective subjects. The Editor and his authors are to be congratulated on the fact that they have adhered strictly to their subject as indicated in the title. "Surgical Diagnosis" is the key-note of the work and it will probably be looked to as the standard on this subject for some time to come.

In a composite work of this kind it is usually possible to select points here and there that are not quite up to the mark. These volumes are so good on the whole that it would be a work of supererogation to pick flaws.

**MINOR SURGERY.** By Arthur E. Hertzler, M.D., and Victor E. Chesky, M.D., Ed. 2. 602 pp., 475 illus., St. Louis, C. V. Mosby Co., 1930.

According to the Preface "this book is wholly to aid the dispensary student to understand what he sees in his daily work and to enable him to gain a general perspective of the subject which may be only partly illuminated by his clinical observations." The fact that a second edition has been called for within three years would indicate that this object has been attained. The authors frankly state that no attempt has been made to include methods not used in the Halstead Clinic. For this reason detailed criticism would be unfair as would also be discussion as to what is included or omitted in a volume on "Minor Surgery." This work is the expression of Dr. Hertzler's ideas and as such it is stimulating and of great interest.

**SYPHILIS HÉRÉDITAIRE DU SYSTÈME NERVEUX.** By L. Babonneix. 432 pp., 54 illus., Paris, Masson et Cie, 1930.

The old question of hereditary and syphilis is discussed in detail in this 432 page book. The subject is well covered, with a final chapter on treatment that is practical and up-to-date. As is unfortunately true of most French books,

there is no Index but a fairly good Table of Contents.

**PHYSIKALISCHE-CHEMISCHE PROBLEME IN DER CHIRURGIE.** Von Dr. C. Häbler. 284 pp., 62 illus., Berlin, Julius Springer, 1930.

The author is in the unusual position of having put in many years in the physiological laboratory followed by extensive experience as a practical surgeon. He is, therefore, well equipped for the production of this volume, which will be found an invaluable guide to modern methods of investigation by every German reading surgeon. It is to be hoped that an equally thorough study of the subject will soon be made available in English.<sup>1</sup>

**DEDICATION OF THE MONTGOMERY WARD MEMORIAL BUILDING.** Northwestern Univ. Medical School. Alexander McKinlock Memorial Campus. 203 pp., Illus. Chicago, 1929.

This is a splendid volume edited by Irving S. Cutter, Dean of Northwestern University Medical School. It is divided into five parts:

Part One is Introductory and tells of Mr. Ward and other contributors to Northwestern University Medical School. Part Two gives the history of the school and Part Three tells of the opening of the Archibald Church Medical Library and the unveiling of twelve portraits in connection with these ceremonies. There is also the story of the dedication of the Departments of Pathology, Bacteriology, Physiology and Anatomy. Part Four is headed "General Addresses" and begins with the "Problems in Medical Education" by Charles H. Mayo.

Part Five has a special collection of papers headed "Scientific Presentations." These papers are models of concise, well edited "theses" and are exceedingly well illustrated.

#### OBSTETRICS FOR NURSES

A Syllabus of Lectures on Obstetrics for Nurses has been prepared by a Committee appointed by the American Gynecological Society and is now ready for distribution to those interested in the subject of nurse training. Copies may be obtained from the Chairman of the Committee, at the nominal price of fifty cents by addressing a request to 23 East 93rd Street, New York City.

PROGRESSIVE MEDICINE. A Quarterly Digest of Advances, Discoveries and Improvements in Medical and Surgical Sciences. Ed. by Hobart Amory Hare, M.D., LL.D. Assist. by Leighton F. Appleman, M.D. Vol. II. 416 pp., 54 illus., Phila., Lea & Febiger, 1930.

The contents of this volume are as follows: Hernia; Surgery of the Abdomen, Exclusive of Hernia; Gynecology; Disorders of Nutrition and Metabolism; Diseases of the Glands of Internal Secretion; Diseases of the Blood and Spleen; Ophthalmology. The subjects are presented in concise, readable and up-to-date form.



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A CLINICAL STUDY OF THE  
ABDOMINAL CAVITY AND PERITONEUM

EDWARD M. LIVINGSTON, M.D.

PUBLISHED SERIALY IN

*The American Journal of Surgery*

SEVENTH INSTALLMENT

SECTION II. THE GASTROINTESTINAL TRACT (CONTINUED)

[In the following pages the Journal page number will be found at the bottom of the page.]

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# A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

## SECTION II. THE GASTROINTESTINAL TRACT

### A. BASIC EMBRYOLOGICAL CONSIDERATIONS (*Continued*)

2. THE ORIGIN OF THE PERITONEAL CAVITY. A description of the development of the peritoneal cavity, stated in broad terms and without regard to details, is as follows: The embryo (Gr. *embryon*, a rudiment; the product of conception during the first three months of intrauterine life) first consists of a flat structure known as the disc, plate or embryonic streak. This is composed on its dorsal surface of a layer of ectoderm and on its ventral surface of a layer of endoderm (Fig. 101A); between these primary layers there subsequently appears a mass of mesoderm, and the earliest suggestion of the future peritoneal cavity is seen when on each side of the midline this mesoderm splits into two layers leaving between a cleft or space (body cavity or celom). (Fig. 101B). As the embryo subsequently changes from its original flat shape and becomes transformed into a cylindrical structure, these two lateral clefts approach one another ventrally (Figs. 101C and D) where they finally fuse in the median plane, completing, thereby, the closure of the gastrointestinal tract, the formation of the anterior abdominal wall and the creation of the celomic or peritoneal cavity (Fig. 101E). The abdominal portion of the body now consists, as previously described, of a tube suspended within a tube (see formation of gastrointestinal tract). The inner tube (bowel) is attached to the outer tube (body wall) by suspending masses of mesoderm which are situated in the median plane. The attachment running to the bowel from the posterior abdominal wall is termed the primitive dorsal mesentery and the attachment passing to anterior surface

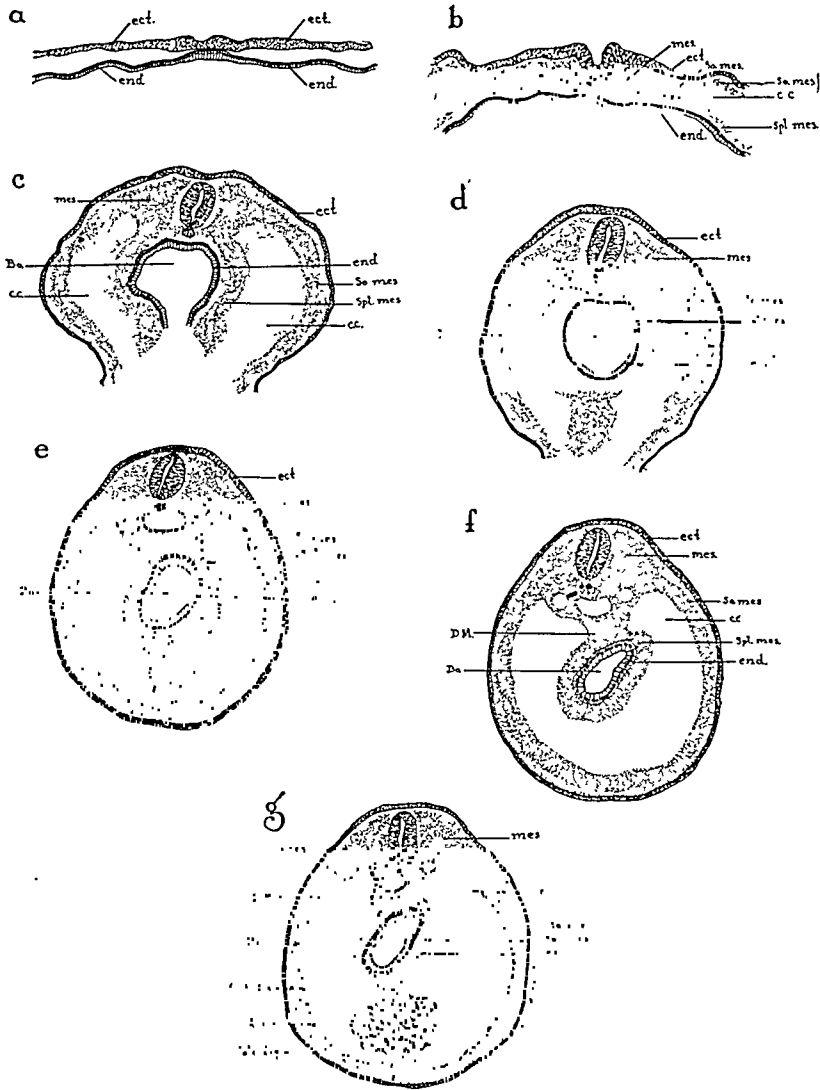


FIG. 101. Origin of peritoneal cavity.

a. The embryonic rudiment (flat structure) situated between the amnionic cavity (ectodermal) posteriorly and the yolk sac (endodermal) anteriorly.

b. Later stage showing mesoderm with the mesodermal clefts which represent the earliest evidence of a future peritoneal cavity.

c. These mesodermal clefts, formed by the splitting of this germ layer into the splanchnic and somatic mesoderm, approach one another as the embryo grows forward to form the anterior abdominal wall.

d. Later stage in which the endodermal layer has fused to form the enteric canal.

e. Still later stage in which the ectodermal layer has also fused, forming the anterior body wall. The peritoneal cavity is enclosed between bowel and body walls.

f. Cross section below level of umbilicus. The inner tube (bowel) is suspended by a dorsal mesentery within the outer tube (body wall).

g. Cross section above level of umbilicus. Here the bowel is supplied with a ventral as well as a dorsal mesentery. Note developing liver within the ventral mesogastrium.

ect, ectoderm; end, endoderm; mes, mesoderm; so. mes., somatic mesoderm; spl. mes., splanchnic mesoderm; c.c., celomic cavity; bo., bowel lumen; d.m., dorsal mesentery; g.h. lig., gastrohepatic ligament; liv., liver; falc. lig., falciform ligament.

of bowel from the anterior body wall is termed the primitive ventral mesentery (Fig. 101F). Below the level of the umbilicus no ventral mesentery exists so that here anteriorly the space is undivided (celomic or peritoneal cavity; Fig. 101G). But above the umbilicus this ventral mesentery persists and here the peritoneal cavity always remains more or less divided (see falciform ligament of liver).

The peritoneal cavity is the result, then, of a splitting of mesoderm as this germinal layer divides to adhere in part to the alimentary tube (splanchnic mesoderm) (Gr. *splanchnon*, a viscus); and in part to the outer wall of the body (somatic mesoderm) (Gr. *soma*, a side). And the flat cells which line the cavity and cover the peritoneal membrane are derivatives of primitive mesoderm (the endothelium).

This simple arrangement of the gastrointestinal tract, body wall and peritoneal cavity represents the final state of affairs with certain lower forms of life, but in the body of the human many subsequent changes take place. These are so numerous and complex that to clearly comprehend the manner in which the abdominal viscera ultimately are related to one another and to the body walls constitutes a somewhat difficult task. This task is simplified by recalling that the many ligaments, peritoneal folds, mesenteries and omenta attached to the adult gastrointestinal tract and its outgrowths (digestive glands) *all* are derived from the primitive, simply-arranged ventral and dorsal mesenteries previously described. Were it not for a knowledge of embryology, which makes it possible to trace step by step the changes leading up to final intra-abdominal arrangements, it would prove difficult for the surgeon to possess a satisfactory understanding of the structures with which he must deal upon entering the abdomen.

The attachment, for example, between liver and anterior abdominal wall (falciform ligament), adhering to the embryonic arrangement, lies within the sagittal plane of the body; but the attachment of liver to stomach (gastrohepatic ligament or lesser omentum) lies at right angles to the sagittal plane.



The relationship of these peritoneal folds is readily and simply explained by the rotation of the stomach ( $90^\circ$ ) which carries the gastrohepatic omentum to a transverse plane (see rotations within the gastrointestinal tract). Similarly the adequate comprehension of many details concerning intra-abdominal structure and organization depends upon an understanding of normal processes of development. Why are some portions of the intestinal tube firmly adherent to the parietes while others are freely movable? How does it come about that many feet of small bowel ultimately are suspended from but 6 in. along the posterior wall of the abdominal cavity? Why does the superior mesenteric artery cross over the terminal portion of the duodenum? Why do not the voluminous intestinal loops more often become entangled? What explanation is there for the fact that the root of the transverse mesocolon overlies many structures rather than is attached directly to the parietes?

Obviously a surgeon possessing clear insight into the *modus operandi* through which final arrangements in the abdomen are produced is in a position to know how he may safely proceed while operating (in mobilizing portions of bowel; in avoiding important vessels; in relieving intestinal obstructions; in reducing internal hernias; in segregating segments of intestine or creating short-circuits in the alimentary canal); he is qualified to recognize congenital arrests in development when such are encountered; he can differentiate bands and peritoneal folds which represent normal variations, from those which are abnormal formations; and he can judge with reasonable accuracy when intra-abdominal conditions are, and when they are not, consistent with good functional activity. And the diagnostician is aided no less than the operator by a thorough understanding of developmental details.

Under the headings "The Distribution of the Adult Gastrointestinal Tract" and "Final Attachments of the Gastrointestinal Tract" the attempt is made briefly to deal, by means of an embryological approach, with salient points concerning

adult anatomy. Here, as elsewhere, basic subjects are reviewed for the sole purpose of introducing practical surgical topics. Before proceeding to these new headings a few clinical matters will be dealt with which are based upon the origin of abdominal tissues from the three embryonic germ layers.

Specific examples of the clinical significance of these germinal layers are readily found in the field of oncology. Malignant neoplasms are at present classified largely upon the basis of the tissues from which they arise; two major groups of malignancies are the sarcomata (malignant tumors arising from mesoderm) and the carcinomata (malignant tumors of epithelial origin). At times malignant ulcers of the two types may be differentiated by simple inspection of the ulcer margins. A sarcoma, as a rule, seems to burst through the skin; it simulates a cannon ball pushing through the integument; it appears to be popping-out at the surface; the surrounding skin margins are thinned out; the actual surface ulceration is produced through pressure necrosis while the epidermis itself is never directly infiltrated by the neoplasm, for sarcomatous tissue and epidermis are of totally different germinal origins and the surface involvement is only secondary and indirect (Fig. 102A). With a carcinoma, on the other hand, the skin is unquestionably directly involved by the malignancy; the ulcer margins are hard and thickened; they present a rolled-out appearance which is characteristic; the carcinoma has eaten its way to the surface through a direct involvement of intervening tissues and the skin may appear dimpled, retracted, thickened, puckered and plainly implicated even before the occurrence of ulceration; the situation here represents a tumor within ectodermal tissue spreading throughout more ectodermal tissue (Fig. 102B).

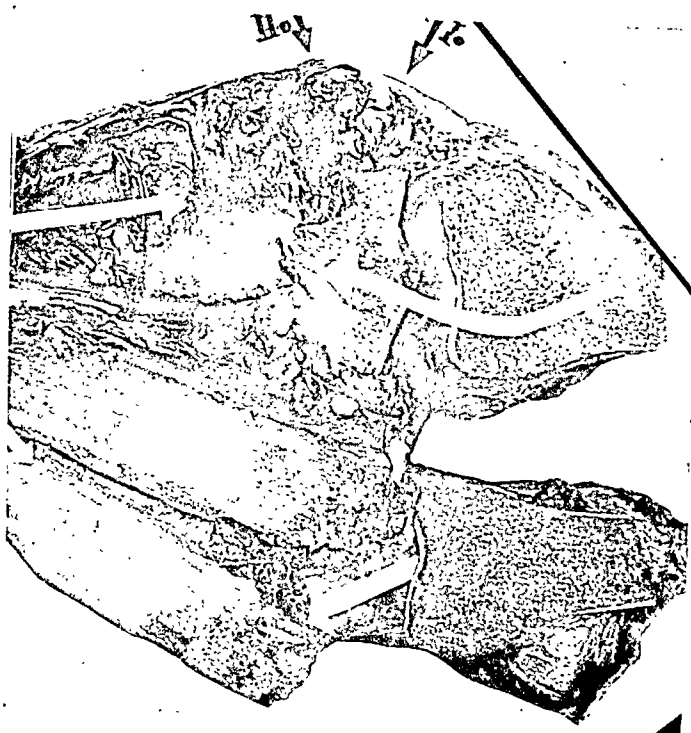
In dealing with tumors of the abdominal walls such distinctions may prove useful in differentiating desmoids (mesodermal origin) from epitheliomata or other ectodermal newgrowths. (For desmoid tumors see page 98.) A desmoid is rounded or ovoid in shape and the skin is approached,

Differentia  
Malignant  
Ulceration

Desmoid T  
vs. Epitheli  
Newgrowth



A



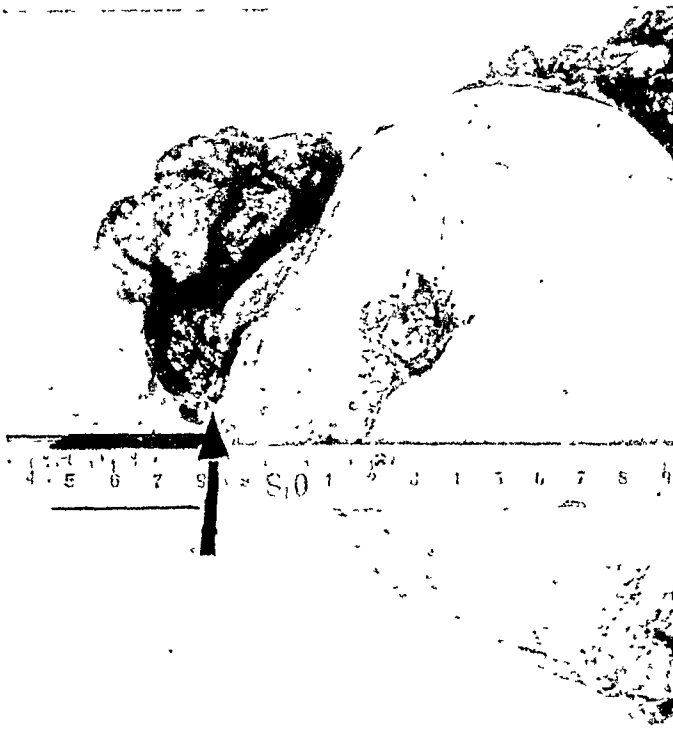
B

FIG. 102 A and B. Sarcoma, a mesodermal neoplasm pushing through ectoderm.  
 A. The new growth seems to burst through the skin. The epidermis is not involved except by pressure necrosis.  
 B. Same growth. Note the thinning out of the integument (1) as the malignant tissue (11) reaches the surface.  
 (From the Third Surgical Division, Bellevue Hospital, N. Y.)

[276]



C



D

FIG. 102 C and D. Carcinoma, an ectodermal neoplasm invading more ectoderm.

c. Note rolled-out margins of malignant ulcer with obvious involvement of the epidermis.

d. Note thickened, rolled-out or everted skin margins at points where the carcinomatous tissue has reached the surface.

(From the Third Surgical Division, Bellevue Hospital, N. Y.)

[277]

as the tumor enlarges, by a surface which is convex, or mound-shaped; the abdominal epithelial surface may be encroached upon but will not be infiltrated by the mesodermal neoplasm. In case of a carcinoma of the abdominal wall the tumor is broad or irregular in shape and the external body surface, if not actually involved from the start, is infiltrated early and by a crab-like extension of the process the skin involvement becomes widespread. From these clinical distinctions it is apparent to the examiner that the desmoid is a neoplasm arising in tissue derived from mesoderm and that the carcinoma deserves its characterization as a malignant tumor arising from epithelium (ectoderm).

Peritoneal  
Neoplasms

Tumors encountered within the peritoneal cavity are more often malignant than benign.<sup>133</sup> But the vast majority of malignancies of the peritoneum are secondary (extensions, transcelomic transplants or metastases from primary tumors of stomach, breast, rectum, uterus, prostate, bile passages, kidney, pancreas; (see malignant peritonitis, p. 192). Primary malignancies of the peritoneal membrane itself are exceedingly rare. Attention will here be focused upon these rare tumors, however, since their occasional occurrence must be kept in mind by the surgeon, who should be familiar with their appearances and manifestations in order to attempt the important differentiation of these uniformly fatal growths from conditions which they tend to simulate (chronic inflammatory exudates, infectious granulomata, pseudomyxoma peritonei). At present there will be excluded from consideration, then, not only the relatively common secondary neoplasms but also the tumors which arise from retroperitoneal tissues (malignant and benign growths springing from lymphatic glands, connective tissue, remains of Wolffian bodies or Mueller's ducts, accessory adrenal bodies); these sometimes grow into the peritoneal cavity in such a fashion as to give the appearance of arising from peritoneal membrane itself and to render the gross differentiation from primary peritoneal malignancies difficult, particularly where the rapid

growth of the retroperitoneal mass into the non-resistant cavity has caused the formation of a pedicle at the peritoneal surface.<sup>134</sup> (For a review of retroperitoneal tumors see Section IV.)

From a study of the germinal origin (embryological development) of the peritoneal cavity (mesoderm) it is seen that primary malignancies of peritoneum must be either endotheliomata or sarcomata. These growths must arise from (1) the endothelium of the serous surface, (2) the endothelium of lymphatic spaces or vessels, or (3) the subserous supporting or connective tissue; all of these are derivatives of mesoderm. Few, if any, tumors have yet been described which could be said to have certainly sprung from the surface cells of the peritoneal membrane, but by the majority of authors primary newgrowths of the peritoneal membrane are regarded as endotheliomata derived from the flat cells of the lymph spaces or lymphatic vessels of the peritoneum. These endothelial malignancies show a marked tendency to a secondary formation of new fibrous tissue (i.e. they display definite sarcomatous tendencies).<sup>135</sup> The terminology for the tumors has been most varied and this is an index as to the variability of the cellular elements which have been observed in different tumors of this type (malignant lymphangiomata; angiosarcomata; plexiform lymphangiosarcomata or endotheliomata,

Primary  
Malignancies of  
Peritoneum

But the surgeon is less interested in details of histogenesis and terminology than in clinical appearances and potentialities. In the main, primary malignancies of the peritoneum may be said to be of 3 chief clinical types; (1) those characterized by a diffuse, shaggy, infiltration of the peritoneal surface at the involved site and closely resembling chronic inflammatory exudates; (2) those characterized by multiple miliary translucent nodules closely resembling the lesions of miliary tuberculosis; and (3) those characterized by the association of villous or papillary elevations with multiple cysts, usually of small size, distributed, often widely, over the peritoneum covering the viscera and parietes.

At times the lesions are highly characteristic and the peritoneum everywhere is covered by these tiny nodules, plates, papillary or villous elevations, or again by small malignant cysts, with or without associated solid nodules; the diaphragm may be perforated by the process and the pleural surfaces involved, or the pleura may be simultaneously involved by endotheliomata without gross perforation of the midriff.<sup>136</sup> Single endotheliomatous nodules may fuse and adjacent layers of peritoneal membrane become adherent. Particularly where the cystic variety of tumor is encountered, do universal adhesions tend to develop, together with marked thickening of mesentery and omentum. It has frequently been observed that endotheliomata seem to spring from many peritoneal sites simultaneously, a circumstance in which they thus vary from carcinomatous lesions. Diagnosis is difficult and usually is arrived at only by the process of exclusion. The tumors may be unexpectedly encountered during explorations conducted because of vague abdominal signs and symptoms, or they may be accidentally discovered in the course of operations for other conditions. The presence of a bloody peritoneal fluid is of great significance and should always excite suspicion of malignant peritonitis. Primary malignancies are distinguished from the secondary variety by the finding of the primary tumor or, in its absence, noting one of the characteristic pictures already described. The absolute differentiation of a primary newgrowth of peritoneum from a chronic inflammatory exudate or from a tuberculous peritoneal lesion can sometimes be made only by microscopic examinations. The importance of securing fragments of excised tissue for laboratory examination, and of saving the bloody fluid for the identification of its contained cells, can scarcely be overstated. The differences in prognosis with the different lesions are so great that there seems no excuse for completing an operation in which doubt remains without obtaining material to be submitted to a competent pathologist. Instances have been reported in which, after abdominal closure for a

supposed<sup>1</sup> primary malignancy, not confirmed by microscopic examination, the patient has recovered. Proved primary malignancies are uniformly fatal; no effective treatment by rays, injections or operations has been discovered.<sup>137</sup> Treatment, then, is simply supportive, palliative and symptomatic. Rapid emaciation is the rule. The average life expectancy after the onset of symptoms with primary malignancies of the peritoneal membrane is but eight and a half months.

The importance of the germinal origin of any tissue is sufficiently great to warrant a tabulation or summary of the relationships, on this basis, of all abdominal structures. From ectoderm are derived<sup>138</sup>: (1) The epidermis of the abdominal walls and epidermal derivatives, hair, epidermal glands; (2) all abdominal nerves and nervous elements, vagi, sympathetic ganglia and fibers, cerebrospinal nerves, adrenal cortex, chromaffin bodies. From endoderm are derived: (1) The inner lining (epithelial lining) of the digestive tract and its derivatives, duct systems of liver and pancreas; (2) the epithelium (inner lining) of the bladder. From mesoderm are derived: (1) The lining membrane of the serous cavity (peritoneum); (2) all muscles, both the striated variety in the abdominal walls and the smooth variety found in the walls of intestines and ducts; (3) all connective tissues, areolar, fibrous, fatty; tendons, ligaments, fascias; (4) all vessels of the circulatory system, veins, arteries, capillaries, lymph vessels and spaces; and also the blood and lymph themselves; (5) the kidneys and ureters; (6) the internal organs of reproduction.

The intestine, then, has an inner lining of endodermal origin, an outer lining (muscle, serosa) of mesodermal origin and nerves and plexuses of ectodermal origin (Fig. 103). The liver has a duct system derived from endoderm, nerve elements of ectoderm and a cellular, capsular, and supporting portion of mesodermal origin. In this way the germinal layers from which the tissues of each viscus spring may be easily recalled and visualized.

Germinal Origin  
of Abdominal  
Structures



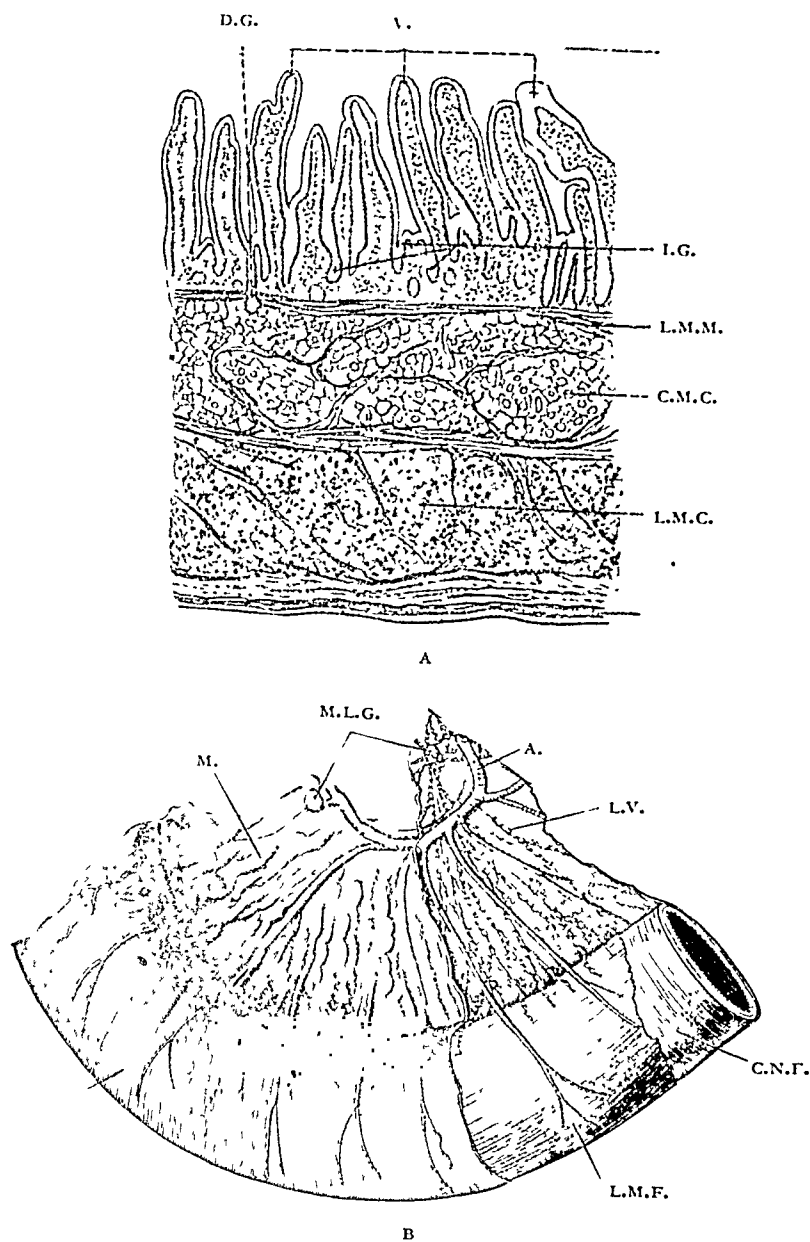


FIG. 103 A and B. Structure and coats of bowel, showing development from three embryonic germinal layers: From ectoderm, the nerve elements. From endoderm, the mucous lining. From mesoderm, the peritoneal layer, muscular layers, vessels, fibrous and areolar issues. (From Cunningham.)

D.G., orifice of duodenal gland of Brunner; v., villi; I.G., intestinal glands of Lieberkuehn; L.M.M., lamina muscularis mucosae; C.M.C., circular muscular coat; L.M.C., longitudinal muscular coat; M., mesentery; M.L.G., two mesenteric lymph glands; A., artery; L.V., lymph vessel; C.M.F., circular muscular fibers; L.M.F., longitudinal muscular fibers.

By knowing the germinal origin of a tissue the clinician is in a position to predict with fair accuracy not only the types of newgrowth to which it is liable, but also its general functions; how it will respond to various stimuli (chemical, electrical, psychic), and many other broad considerations of great moment. Abdominal organs or parts of organs, which spring from a common germinal ancestry display similarities and affiliations as such relationships imply. Widely distributed throughout the abdomen, for example, are found small, independent, encapsulated collections of cells of ectodermal origin which have in common the fact that they stain yellow or yellowish-brown in the presence of chromic salts; these are collectively called chromaffin bodies and they, together with cells of the adrenal medulla which take the same stain, are referred to as the chromaffin system.<sup>139</sup> Histogenetically these chromaffin staining tissues are closely identified with the ganglia of the sympathetic nervous system. And the functional similarities between the sympathetic ganglia and the adrenal medulla are well-known (see Visceral Neurology). Interrelationships of the most profound importance between skin, spinal ganglia, sympathetic ganglia, and chromaffin system (all ectodermal derivatives) will later be reviewed, and throughout the text numerous subjects will be found more readily understandable as the surgeon recalls the embryological origin of the tissues involved and the manner in which they are related to other tissues of the body.

Through his knowledge of tissue relationships the broadly trained clinician is in possession of a sound basis upon which to interpret much otherwise unrelated data gathered from the spheres of the many specialties. The basic laws of nature are few. And these tend to be essentially simple. The various actions throughout the body, for example, of adrenalin, pituitrin, thyroxin, pilocarpine, and other drugs might prove difficult even to memorize were it not for the generalizations made possible through knowledge of tissue origins and similar tissue functions. It is a truism that the body is a functional

The Chromaffin  
System

The General  
Practitioner and  
the Specialties

unit, not a series of unrelated parts. And while specialists (the gynecologist, proctologist, cardiologist, ophthalmologist, etc.) are familiar with many facts concerning individual tissues within their respective fields, gained through first-hand observation and representing the accumulated experience from handling vast numbers of cases, the competent general practitioner or diagnostitian, though totally lacking in prolonged and extensive experience in each special field, is able, through the use of analogies and the application of broad principles, to become well versed as to local conditions and to understand his patient as an entity. The specialist offers the patient advantages of detailed knowledge and a high degree of technical skill within a limited field, but it is the general clinician who protects the patient both from study or treatment from a limited point of view, and retains that broad perspective and understanding so essential to unbiased judgment as to the best interests of his patient as an individual.

Since adjacent intra-abdominal tissues are sometimes totally unrelated while those situated at a distance from one another may spring from a common source, it proves advantageous, for numerous reasons, that the practical surgeon bear in mind, and frequently review, the germinal origins of the tissues with which he deals.

3. THE DISTRIBUTION OF THE ADULT GASTROINTESTINAL TRACT. In reviewing the manner in which the enteric canal is normally arranged within the abdominal cavity the following points will be taken up in the order named: (a) the rotation of the stomach; (b) the position of the duodenum; (c) the formation of the duodenojejunal juncture; and (d) the rotation of the intestines.

*a. Rotation of the Stomach.* The stomach develops as an enlargement of the foregut (Fig. 104). At first fusiform (fourth week) this embryonic viscus rapidly assumes the shape of the adult stomach through an elongation and enlargement of the posterior gastric wall. With this excessive growth and the formation of the fundus and greater curvature, more space is

required than is provided in the midline of the body and it becomes necessary that the stomach rotate in some direction. The presence of the enormous embryonic liver to the right

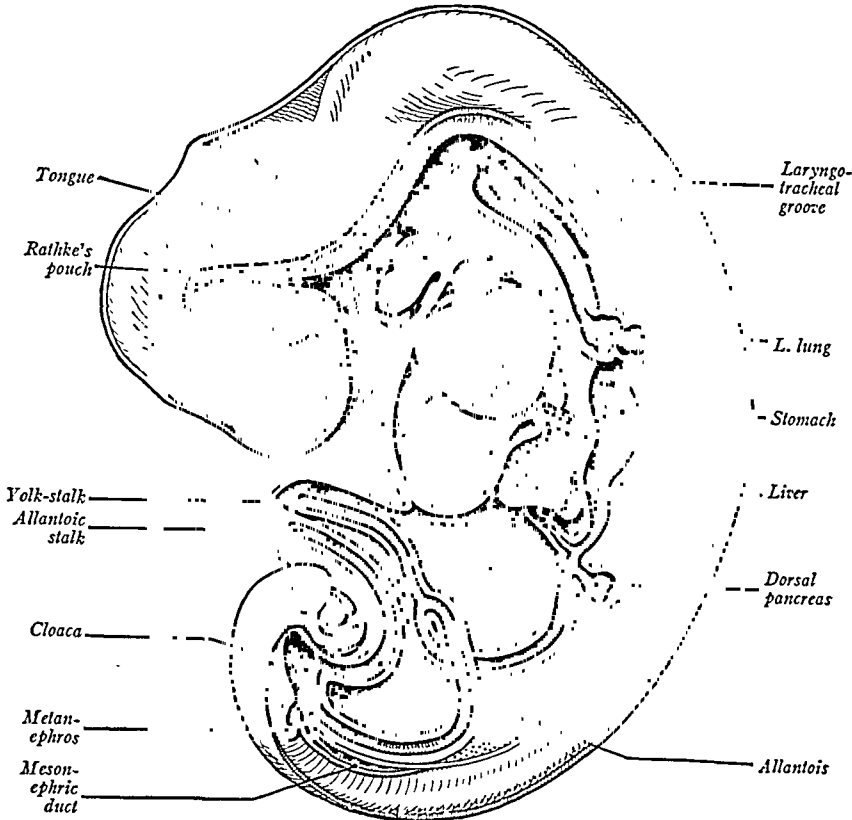


FIG. 104.—Origin of stomach from foregut. The entire enteric canal with all its derivatives and its early anatomical relationships is shown. (From His.)

causes the largest part of the stomach (fundus) to pass to the opposite side of the abdomen (fundus to the left) and as a result the lesser curvature and smaller end of the stomach (pylorus) come to be lodged beneath the liver (Fig. 104). By this rotation of  $90^\circ$  in which the stomach assumes its position transversely within the upper abdomen the original right side of the stomach comes to face posteriorly while the original left side faces the front. Thus is explained the apparent asymmetry of the vagus nerves with the distribution of the left vagus to the front of the stomach and the right vagus to the posterior gastric wall.

Distribution of the  
Left Vagus to  
Anterior Gastric  
Wall

*b. Position of Duodenum.* As the pylorus moves toward the right it carries with it the attached portion of small bowel. But since the dorsal mesentery is fixed to the midline this proximal bit of small intestine (duodenum) is thrown into a loop which passes first to the right, then downward, then back to the left: And this explains the formation of its three anatomical divisions. In the adult the first portion measures 2 in. and passes backward almost horizontally toward the upper end of the right kidney; the second part, 3 in. in length, descends vertically in front of the inner border of the kidney to the level of the third lumbar vertebra, and is crossed at about its middle by the root of the transverse mesocolon; the third portion, 5 in. in length, crosses from right to left in front of the third lumbar vertebra and then ascends for a short distance on the surface of the left psoas muscle to end at the duodenojejunal junction. These 3 divisions are termed, respectively the horizontal, the descending and the ascending portions (Fig. 105). From the surgical point of view a more practical division of the duodenum is that determined by the passage over this structure of the root of the transverse mesocolon which, in bisecting the loop, creates a supracolic half (to be examined from above) and an infracolic half (to be seen only after lifting the transverse colon and mesocolon). (See Fig. 107.)

The portion of duodenum immediately adjacent to the pylorus is known as the bulbus duodeni, duodenal vestibule or cap. Approximately 80 per cent of duodenal ulcers occur within this "bishop's" cap.<sup>140</sup> The content of the duodenum is normally alkaline in reaction, due to the bile and pancreatic juice, but the bulbus duodeni, because of its location, is directly exposed to the acid gastric contents. Hence these ulcers are termed "peptic." The most frequent site for such ulcers is on the ventral wall of the duodenum and within 2 to 3 cm. of the pyloric ring. It has been pointed out that of all diagnostic data which points to peptic ulcer, the foremost evidence is the one symptom, pain (see p. 260) and that a

Divisions of  
Duodenum

The Duodenal  
Cap

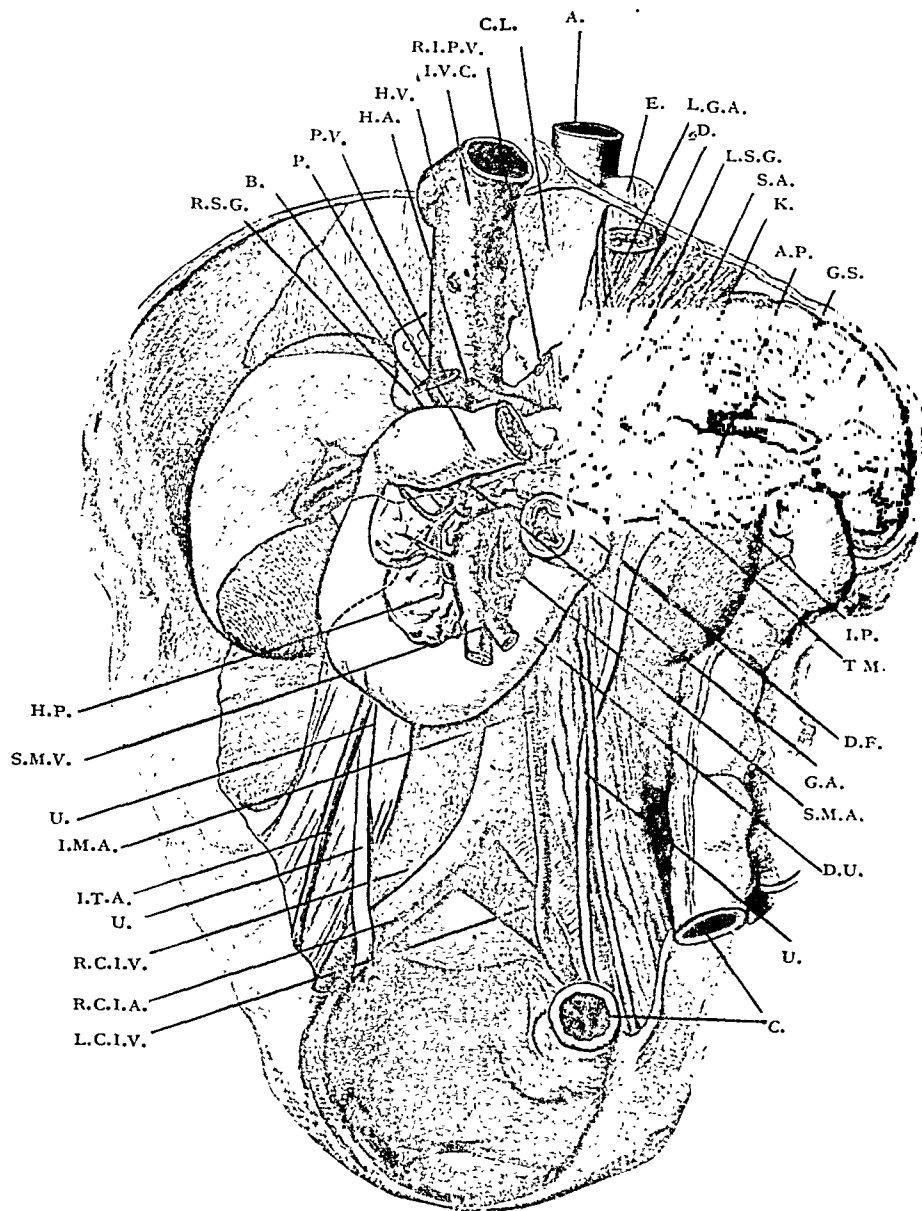


FIG. 105.—Divisions and ultimate relationships of duodenum (stomach, liver, and most of intestines have been removed). (From Cunningham.)

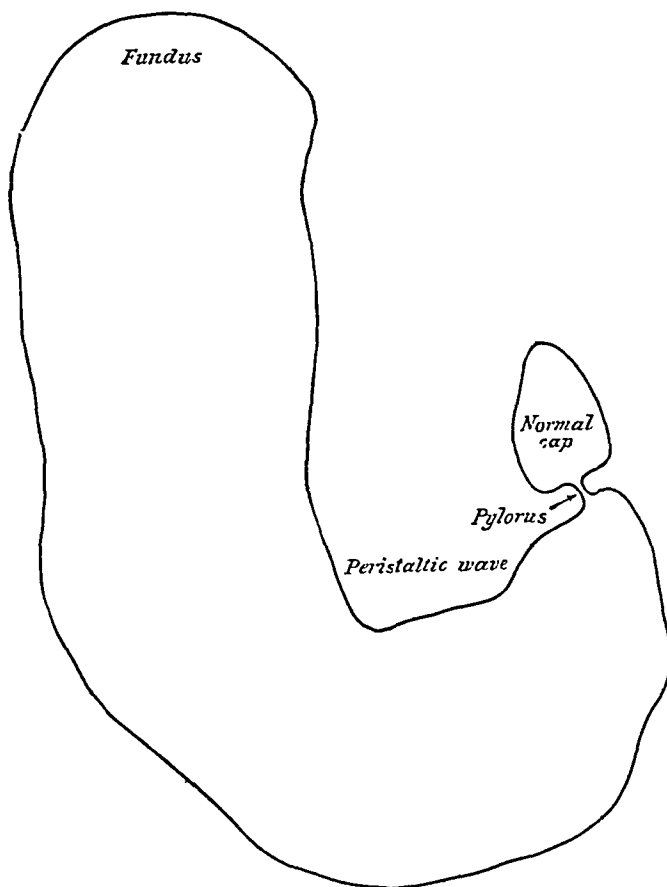
A., aorta; C.L., fossa for caudate lobe; R. I.P.V., right inferior phrenic vessels; I.V.C., inferior vena cava; H.V., hepatic vein; h. a., hepatic artery; P.V., portal vein; P., pylorus; B., bile-duct; R.S.G., right suprarenal gland; E., esophagus; L.G.A., left gastric artery; D., diaphragm; L. S.G., left suprarenal gland; S.A., splenic artery; K., kidney; A.P., anterior surface of pancreas; G.S., gastric surface of spleen; H.P., head of pancreas; S.M.V., superior mesenteric vein; U., ureter; I.M.A., inferior mesenteric artery; I.T.V., internal testicular vein; R.C.I.V., right common iliac vein; R.C.I.A., right common iliac artery; L.C.I.V., left common iliac vein; I.P., inferior surface of pancreas; T.M., attachment of transverse mesocolon; D.F., duodenojejunal flexure; G.A., gastroduodenal artery and neck of pancreas; S.M.A., superior mesenteric artery; D.U., duodenum; C., colon.

typically cyclic or regular discomfort with relation to the intake of food constitutes presumptive evidence of ulcer. But next in order of diagnostic value comes the finding upon radiographic examination of persistent deformity of the duodenal cap.<sup>141</sup>

This duodenal cap is normally the only portion of the duodenum plainly seen upon the radiographic film (Fig. 106). This is true partly because the opaque medium is greatly diluted by the large quantity of duodenal digestive secretions and partly because the entire remaining length of duodenum is very rapidly traversed by the food (twenty-five to sixty seconds) so that the walls of the second and third portions are but poorly visualized.<sup>142</sup> The first portion of duodenum presents a shadow which is somewhat triangular in shape; its base is directed toward the pylorus and its walls are normally quite smooth (duodenal cap). A thin line (barium stream) may connect the cap and stomach shadows, providing the pylorus is open (Fig. 106). The duodenal shadow is studied as to location, size (dilated; constricted), shape (regular; irregular), and rate of filling or emptying (rapid; slow). The findings upon x-ray examination when a duodenal ulcer is present, are: (1) Persistent deformity in outline in the duodenal cap; (2) changes in duodenal motility; (3) secondary changes in gastric peristalsis (gastric hypermotility is an almost invariable accompaniment of duodenal ulcer); (4) niche formation. Cap deformities with ulcers are constant; deformities due to simple muscle spasms vary upon different examinations. The persistent deformity most typical of duodenal ulcers is of a coral shape. Accompanying Figures show the characteristic association of gastric hypermotility, coral shadow, and an incompetent valve with its thin barium stream joining duodenal cap-shadow with the gastric shadow. It has been stated that in competent hands radiographic study should demonstrate 90 per cent of ulcers,<sup>143</sup> and that roentgenographic examination alone is more accurate than all other diagnostic methods combined. The presence of either typical history (characteristic pain) or typical



A



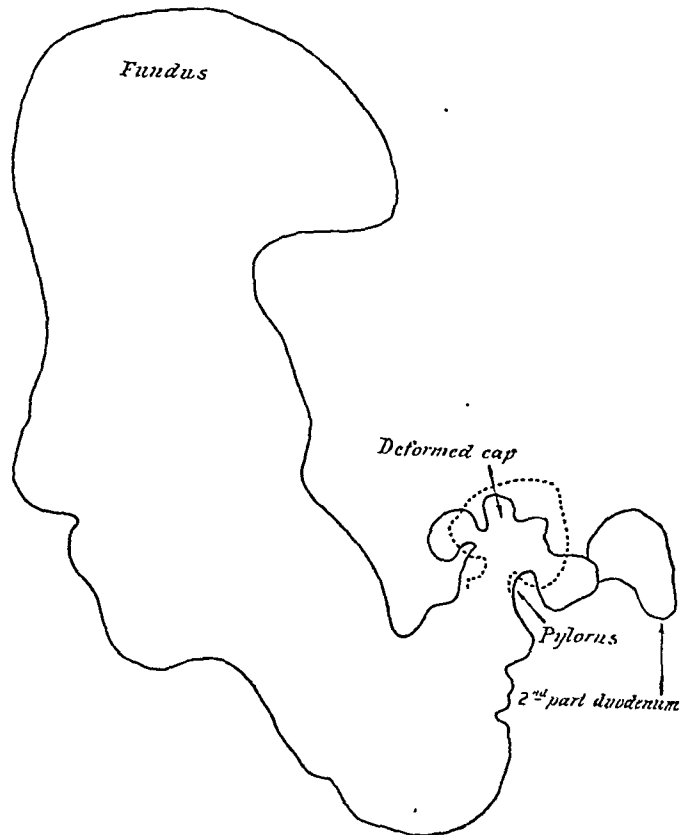
B

FIG. 106 A and B. Roentgenogram and tracing of normal duodenal cap. Note shape of stomach and duodenal cap, also barium stream representing the patent pylorus. (From Holmes and Ruggles, Roentgen Interpretation, Lea and Febigar.)





C



D

FIG. 106 C and D. Changes in stomach and duodenum caused by duodenal ulcer. Note hyperperistalsis of stomach and typical "coral" shaped deformity of duodenal cap. (From Holmes and Ruggles, Roentgen Interpretation, Lea and Febiger.)

x-ray findings furnishes presumptive evidence of ulcer, but the association of the two may be considered diagnostic.

Radiographic evidence, as is true of any single finding, is not infallible. Adhesions between duodenum and other structures, (for example the gall bladder), and pressures upon the duodenal cap from without, (tumors) are conditions which cause such mimicry as to the shadows produced that both radiographer and clinician must be constantly upon the alert. Adhesions around the duodenum, it is true, produce irregularities which are relatively slight and which tend to change with changes in the position of the patient or in the lines of traction upon the duodenum; periduodenal adhesions also cause a quite characteristic fixation of the cap which is absent with uncomplicated ulcers. Yet these differential points are not always well marked and the x-ray evidence may not be relied upon implicitly.<sup>144</sup> The deformities of cap caused by pressures from without are in the nature of smooth indentations rather than coral-shaped distortions. But there remain sufficient doubt and a sufficient percentage of errors to warrant care and conservatism in the interpretation of roentgenograms. It is probably true that actual duodenal ulcers are less frequently missed by radiographic examinations than are supposed ulcers found which can not be proved by subsequent operation or autopsy.

A notable cause for diagnostic errors from radiographic examinations for duodenal ulcers is the persistence of scars and deformities after previously existing ulcers have healed. The ulcer scar, as a scar anywhere in the body, tends to be permanent. Given then, a patient who has once had a deep duodenal ulceration, subsequent study by means of x-rays will often reveal a persistent deformity of the cap. Because of this fact, with these patients gastrointestinal symptoms due to other lesions are liable to misinterpretation and an ulcer may be considered active as judged by the radiographic film, when in reality it is quiescent or healed. The statement bears repetition that all diagnostic data must be correlated if errors are to be avoided.

Correlation of  
Data

Limitations of  
Radiographic  
Study

Persistent  
Deformity of the  
Cap

Surgical  
Significance of  
Duodenojejunal  
Junction

c. *The formation of the duodenojejunal junction.* The point of union of duodenum with jejunum is of considerable importance as an intra-abdominal landmark. From this point measurements are taken for the site of the opening in the jejunum for simple jejunostomy, for gastroenterostomy or for cholecystenterostomy made by the retrocolic route of anastomosis. The junction also marks the uppermost point of origin of the adult mesentery (the jejunoileal mesentery) and at this point the following three peritoneal reflections meet, the under surface of the transverse mesocolon, the upper extremity of the right leaf of the mesentery, and the posterior parietal peritoneal reflection as it covers the terminal duodenum. The junction of duodenum and jejunum is synonymously termed the duodenojejunal angle. The angulation is caused by the fact that the terminal (third or ascending) portion of the duodenum is directed backward and slightly upward while proximal jejunum passes downward and to the left (Fig. 107).

Locating the  
Proximal  
Jejunum

The duodenojejunal junction lies slightly to the left of the second lumbar vertebra; it is at this point that the jejunum appears to suddenly enter the peritoneal cavity from below the transverse mesocolon (Fig. 108). The reason for this abrupt entrance of the jejunum into the greater peritoneal cavity will be explained with the study of the rotation of the small intestine). The proximal portion of the jejunum is located by drawing the transverse colon strongly upward, then passing the index finger along the under surface of the root of the transverse mesocolon; the desired segment is hooked up at the point where the bowel pierces the mesocolon just to the left of the spinal column to enter the infracolic division of the general peritoneal cavity. During these maneuvers the forefinger enters a small recess located just to the left of the second lumbar vertebra immediately below the inferior surface of the body of the pancreas. The superior mesenteric vessels are palpable to the right of this point of origin of the jejunum; they mark the upper extremity of the mesentery of the small bowel. The first part of the jejunum always

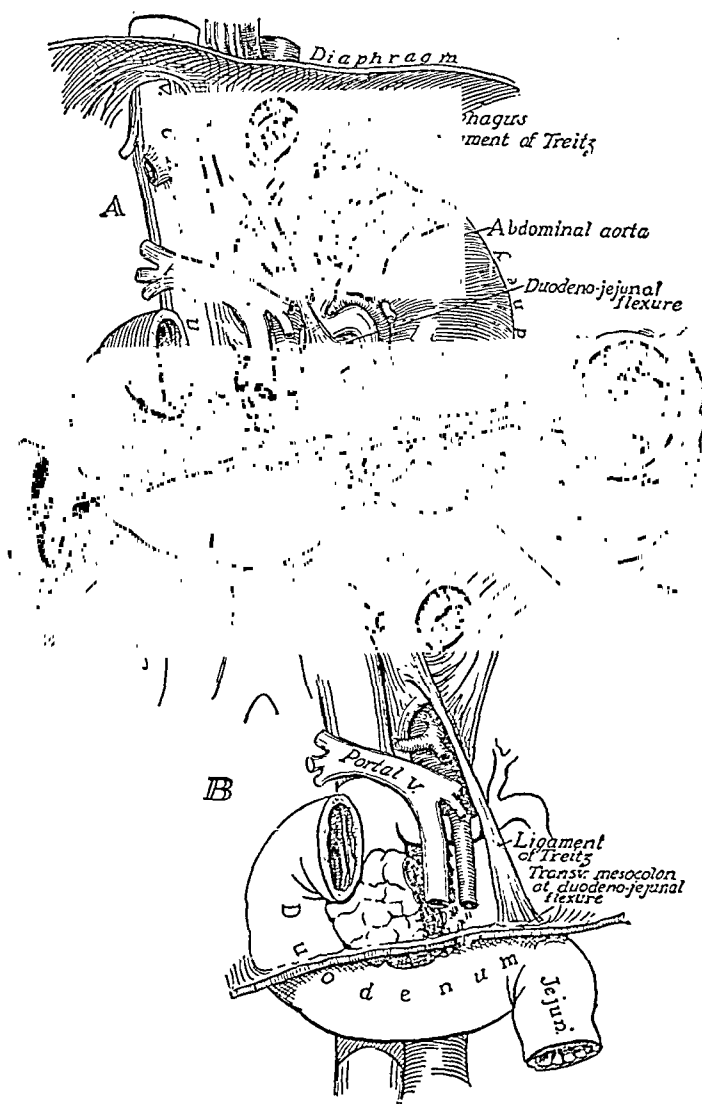


FIG. 107. The duodenojejunal junction or angle. Schematic representation of duodenum and its retroperitoneal relationships. Variations in the angle as described by Roeder.

A. The U-type of duodenum with the ligament of Treitz elevating the duodenojejunal flexure above the transverse mesocolon.

B. The C-type of duodenum with the ligament of Treitz of greater length, allowing the flexure to lie just below the transverse mesocolon. Compare the angulation of the two flexures.

passes downward and slightly to the left from its point of attachment at the duodenojejunal angle: This is the only segment of small intestine the location and direction of which

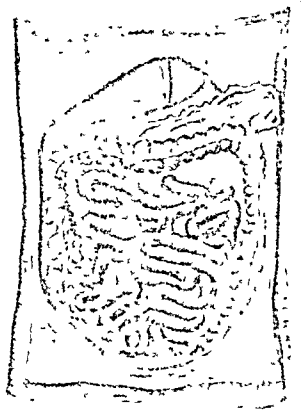


FIG. 108. The jejunum appears within the infracolic division of the peritoneal cavity, springing from beneath the root of the transverse mesocolon.

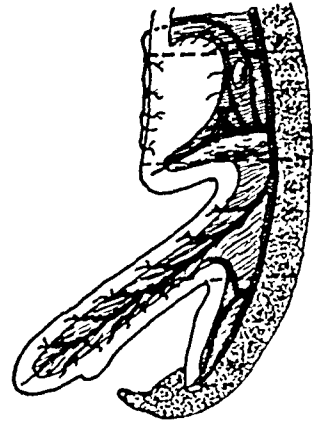


FIG. 109. Review of the parts of the enteric canal at the period marked by presence of primary or umbilical bowel loop. Note position of cecum; arrangement of vessels and of developing glands within the dorsal mesentery.

are constant.<sup>145</sup> The ligament of Treitz proves of service in locating the proximal jejunum by means of simple inspection. This is a fibromuscular band which originates from the right crus of the diaphragm and the tissue about the celiac axis and passes to the duodenojejunal junction; it is often referred to as the suspensory ligament of the duodenum. When the transverse mesocolon is put upon an upward stretch the course of this ligament is visible; the structure in addition may be palpated as it leads, as a guide, to the beginning of the jejunum.

When any doubt remains that the proximal jejunum has been correctly located the following test will settle the matter: pull downward upon the loop in question; if it is found to be fixed, the loop is most certainly the proximal jejunum; but if it is not fixed, and traction results in the delivery of a long portion of bowel, it is obvious that the loop in hand is not located immediately below the fixed duodenojejunal junction and is not proximal jejunum.

A. J. S., n. s. Vol. IX, No. 1, p. 180

The Ligament of  
Treitz

*d. Rotation of Intestines.* The intestines rotate during development upon the superior mesenteric artery as an axis. To understand this phenomenon it is necessary to revert to a study of the primary loop of the primitive bowel (six to ten week embryos) and to visualize the arrangement of the enteric tract at this period (Fig. 109). The primary loop, it will be recalled, consists of a descending limb from which all of jejunum and most of ileum arise; of an ascending limb from which develop the remainder of ileum, and beyond the cecal bud, the cecum, appendix, ascending colon and a large part of the transverse colon; of a vitellointestinal duct, springing from the free bowel border at the apex of the loop and passing to the yolk vesicle; and finally, of a superior mesenteric artery which traverses the entire length of the dorsal mesentery of the loop, supplying all of its derivatives. At this developmental stage the only attachment to the posterior abdominal wall of this entire length of intestines (jejunum, ileum, cecum, appendix, ascending colon, transverse colon) is found at the base of the primary enteric loop; that is, at a narrow mesenteric isthmus extending between the two limbs of the loop at their points of origin. This site of attachment is known as the duodenocolic isthmus; for at the base of the descending (proximal) limb lies developing duodenum, while at the base of the ascending (distal) limb is located the developing colon (a point near the future splenic flexure). This duodenocolic isthmus plays a rôle of the utmost importance in determining the final arrangement of the enteric tract within the abdomen and a close relationship between duodenum and colon is retained throughout life (see duodenocolic ligaments).

Importance of the  
Duodeno-colic  
Isthmus

When the yolk vesicle and vitellointestinal duct become of less importance and begin their degeneration the developing intestines are no longer pulled outward into the umbilical cord but, due to their mesenteric attachment at the duodenocolic isthmus to the posterior abdominal wall, they are drawn back into the abdominal cavity as the embryo elongates and

Reduction of  
Embryonic  
Umbilical  
Herniation  
of Bowel

the abdomen enlarges. So great has been the growth of the derivatives of the primary loop of bowel by the time of their return to the abdomen (particularly of the descending limb with its jejunoileal segments) that they can no longer remain in the midline but must, of necessity, be thrown into turns and coils some of which are oblique and others transverse to the long axis of the abdomen. The phenomenon of intestinal rotation takes place coincidentally with this spontaneous replacement of the intestines into the abdomen. Rotation takes place upon the axis of the superior mesenteric artery at the duodenocolic isthmus<sup>146,147</sup> and continues through an arc of 180°. During the process the ascending or distal limb of the primary intestinal loop comes to overlies the descending or proximal limb (i.e. the large bowel comes to lie on top of the small bowel) and the superior mesenteric artery itself undergoes actual torsion through the half circle (180°) with a resulting complete rearrangement of its peripheral branches (see blood-supply of gastrointestinal tract). As a result of bowel rotation the cecum and appendix are carried to the right upper quadrant to be lodged below the liver (Fig. 110A); the transverse colon comes to be superimposed upon the duodenum; and the terminal duodenum is carried below the superior mesenteric artery near the point of origin of this great vascular trunk. The practical significance of this latter arrangement whereby the superior mesenteric artery crosses over the terminal duodenum has already been discussed during the consideration of that important form of high intestinal obstruction variously known as gastro-mesenteric ileus, duodenomesenteric ileus, or simply as mesenteric ileus (See p. 219).

End-results of  
Intestinal  
Rotation

Fetal Position of  
Appendix; Appen-  
dicitis Simulating  
Cholecystitis

The position of the appendix at the termination of intestinal rotation (below the liver) is but temporary and a rapid growth in cecum follows which carries the appendix to its normal situation in the right lower quadrant. With this descent of the cecum the ascending colon becomes differentiated (Fig. 110B). The right colic flexure (hepatic flexure) of the colon

# DIAGRAM

# DRAWING

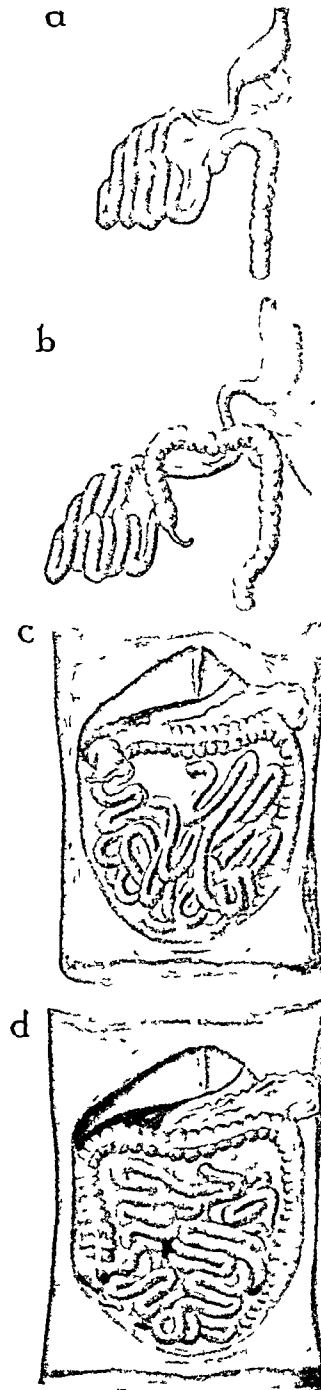
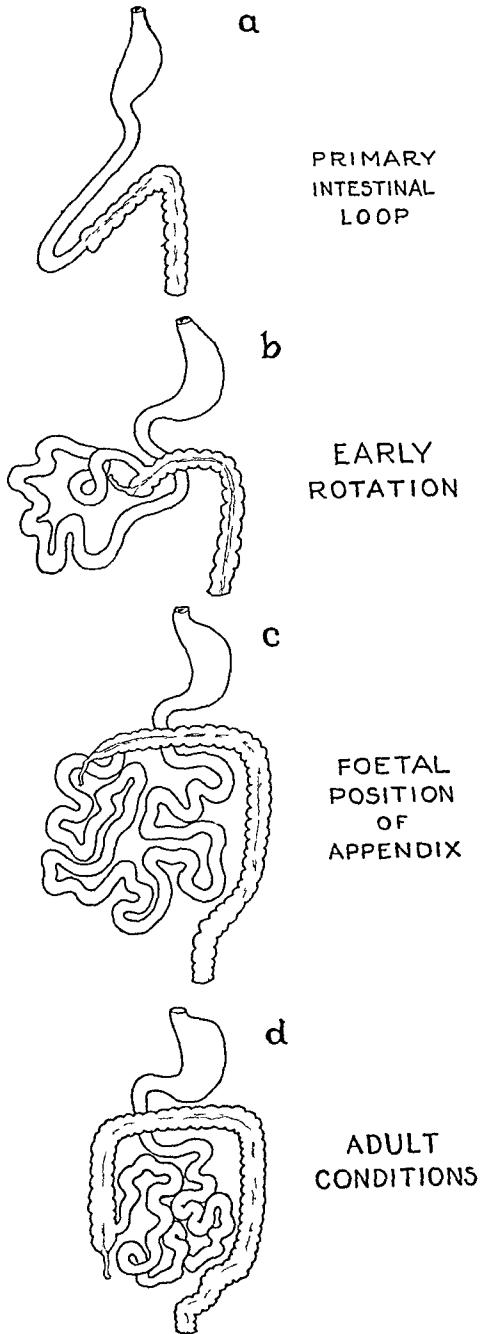


FIG. 110. Changes in enteric canal from period of the primary intestinal loop to establishment of adult conditions (Redrawn after Huntington.)



will be studied more in detail as the liver and gall bladder are subsequently dealt with. Due to faulty development the appendix and cecum, at times, remain in the high or embryonic position. This occurs in about 2 per cent of individuals. In such instances when the veriform appendix becomes acutely inflamed, the signs and symptoms produced are referable to the upper rather than to the lower abdomen and some disorder of the gall bladder or biliary ducts may be closely simulated.

For further study of intestinal rotation reference must be made to special textbooks on embryology or gastroenterology. Both written descriptions and diagrams prove unsatisfactory for clarifying the phenomenon of rotation. The two chief reasons for this difficulty are, first, that three dimensions must be dealt with and second, that during or after rotation certain parts of bowel hide or obscure other parts. It has been pointed out that the alimentary canal of the cat furnishes an excellent model for use in studying the rotation of the intestines and gives a convenient macroscopic illustration of conditions which in humans exist only during early embryonic life.<sup>148</sup> No rotation of the intestines occurs in the cat. Hence the student finds in this animal a simple arrangement of the bowels and by picking up the cat's cecum and placing it below the liver he at once may see the results that would be produced by rotation, and he may then study the secondary changes which are dependent upon the fact that large bowel has been superimposed upon small bowel. Huntington has described a technic for dissecting and thus studying the intestinal canal of a cat and points out that if the main abdominal vessels be injected with liquid plaster-of-Paris a specimen is created which is of particular value for demonstration and which may be kept indefinitely, preserving the entire preparation in a 50 per cent solution of alcohol.

In rare instances an adult human is encountered in whom no rotation of intestines has occurred (Fig. 111A). Here all coils of small intestine lie largely within the midline or right

**A Model for the  
Study of Intestinal  
Rotation**

side of the abdomen while all the large intestine lies to the left side. Hence the abdominal cavity is not divided into supracolic and infracolic divisions; the duodenum, as might be expected in such circumstances, is plainly visible throughout its entire course and is nowhere retroperitoneal; all portions of enteric canal retain mesenteries, including duodenum,

**Non-rotation of the  
Bowel in Man**

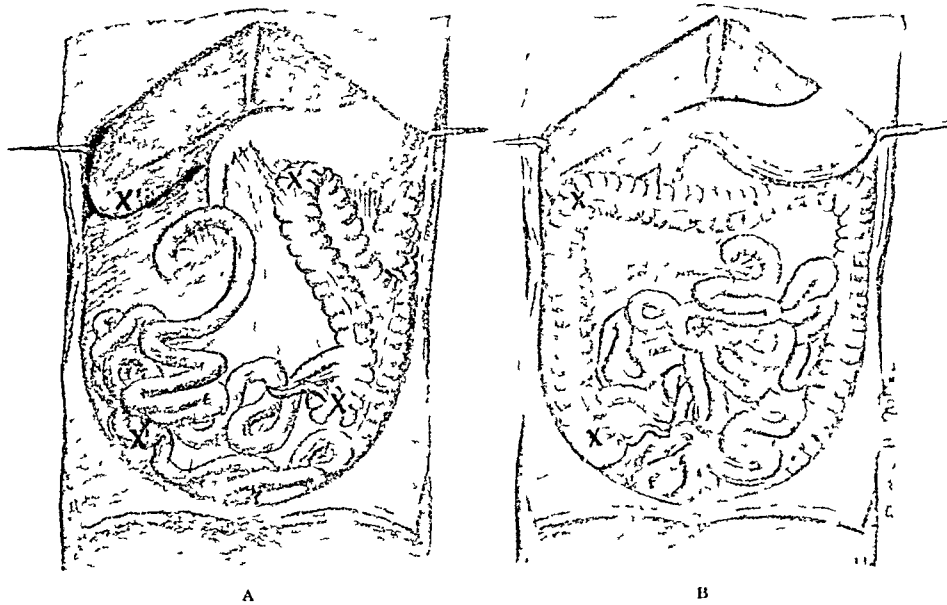


FIG. 111. Study of establishment of final arrangement of gastrointestinal tract within the abdomen.

A. Rare case of non-rotation of intestines in human (redrawn from Huntington).

B. Conditions after rotation has occurred. To place points X and X' on points X' and X' of Figure 111A will immediately explain all of the secondary changes pictured in Figure 111B.

ascending colon, descending colon and colic flexures. Pictures of such cases of non-rotation prove valuable for purposes of study. With such a picture it is possible to imagine picking up the cecum and placing it below the liver (imitating intestinal rotation as it would normally occur; see Fig. 111B where point x is superimposed on point x'). Secondary changes incident to bowel rotation immediately appear: the duodenum is pushed backward against the posterior abdominal wall by the transverse colon and the duodenum is in part obscured

from view; the proximal jejunum appears to pop out from below the transverse mesocolon as it suddenly enters the greater peritoneal cavity; the small intestine appears clumped in the central regions of the abdomen; while the large bowel describes a huge loop traversing the periphery of the abdominal cavity. This final arrangement of small and large intestines makes clear why with small bowel obstructions the center of the abdomen tends to become distended and why typical "ladder patterns" may appear, with midline loops of distended bowel visible externally, one above the other, like the rounds or rungs of a ladder; and explains, also, why with large bowel obstructions, particularly when of sigmoid colon, there may be noted marked distention in the flanks or abdominal circumference associated with a relatively flat or non-distended central region.

Visible Distentions  
of Obstructed  
Bowel

4. *Final Attachments of the Gastrointestinal Tract.* Preceding embryological studies (Origin of the Peritoneal Cavity; Origin of the Gastrointestinal Tract; Distribution Within the Abdomen of the Enteric Canal) furnish a sound basis for a clear comprehension of the manner in which the investing serous membrane ultimately connects the various portions of the alimentary canal and its digestive glands to one another and to the abdominal parietes. These final attachments of the enteric tract prove most complex and difficult thoroughly to understand when dealt with through any other mode of approach.

The gastrointestinal tract always remains basically a midline structure. That there are distinct practical advantages for the surgeon in keeping this viewpoint in mind will be amply illustrated as reliable methods for mobilizing individual anatomical units of the tract are considered and as other technical and diagnostic measures are taken up. Originally a simple straight tube, suspended in the midline by an uncomplicated peritoneal reflection or mesentery, the enteric canal adheres fundamentally to this early arrangement and late developmental changes (final peritoneal attachments) are in

reality superficial in significance as contrasted with the essential design or pattern which is determined in early embryonic life (see vascular, and nerve supply of bowel).

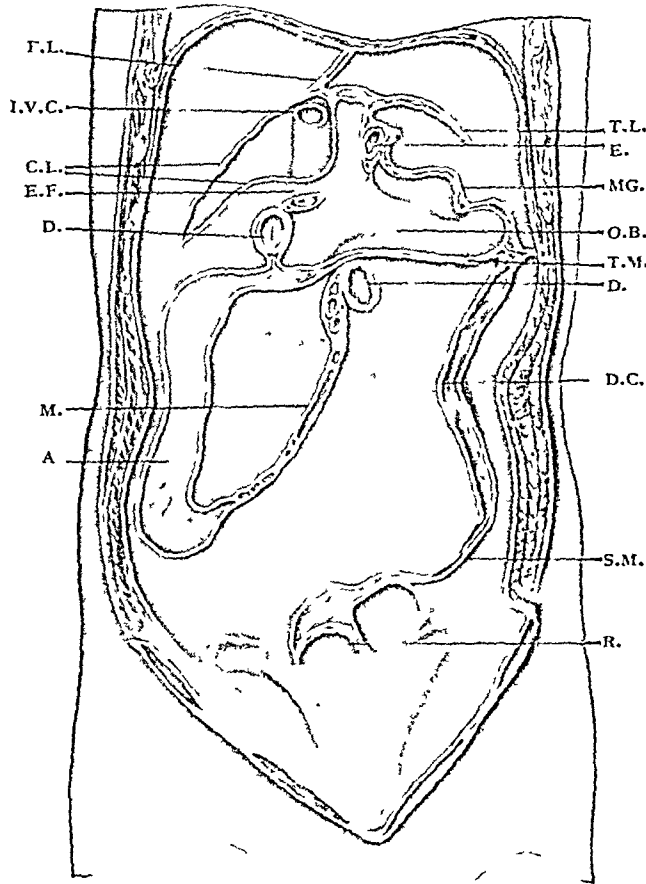


FIG. 112. Empty cavity.

The abdominal organs have been removed, exposing the "raw" or "uncovered" areas of the posterior wall (zones devoid of peritoneum). (After Morris' *Anatomy*, from McMurrich's *Development of the Human Body*, Blakiston.)

F.L., falciform ligament. I.V.C., inferior vena cava. C.L., coronary ligament. E.F., epiploic foramen. D., duodenum. M., mesentery of small intestine. A., area of attachment of ascending colon. R., rectum. S.M., sigmoid mesocolon. D.C., area of attachment of descending colon. T.M., transverse mesocolon. O.B., omental bursa. MG., mesogastrium. E., esophagus. T.L., left triangular ligament.

Under the heading of "Raw" or "Uncovered" Areas of the Abdomen illustrations have been inserted to show exactly the lines of fixation of stomach, intestines and digestive glands, to the abdominal walls (Fig. 112). These sites of attach-

ment will now be minutely studied, together with practical points which bear directly upon such details concerning gastrointestinal fixation and support.

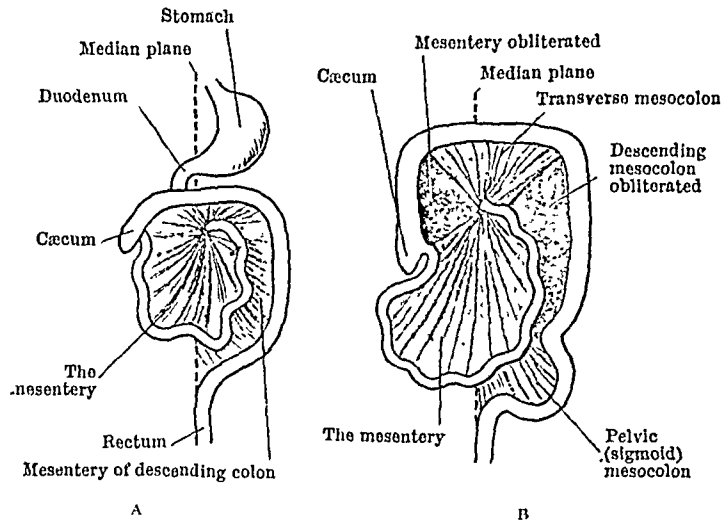


FIG. 113. Ultimate fixations of large bowel.

- A. Entire intestinal tract (large and small bowel) supplied with a dorsal mesentery.  
 B. Later stage, showing (shaded areas) portions of large intestine which become fixed or partially retroperitoneal. (From Cunningham.)

*a. Attachments of the Colon.* Those portions of colon brought into direct contact with the parietal peritoneum (abdominal walls) during the process of intestinal rotation lose their primitive mesenteries and become fixed or partially retroperitoneal; but the portions of colon which at the termination of bowel rotation are *not* in direct contact with abdominal wall but overlie other intra-abdominal structures, retain mesenteries. Thus the transverse colon, which overlies duodenum, is permanently supplied by a transverse mesocolon, and the pelvic colon (sigmoid) which on account of its extreme length is too voluminous to lie smoothly in contact with pelvic peritoneum but necessarily overlies other structures, is always supplied by a mesocolon (pelvic or sigmoid mesocolon; see volvulus). All portions of colon aside from these transverse and pelvic divisions are, as a rule, relatively fixed (Fig. 113). The line of peritoneal reflexion from the ascending

and descending colons onto the posterior abdominal wall runs vertically upward from the centers of the iliac crests. The right colic flexure (hepatic) is fixed at the level of the first lumbar spine; the left colic flexure (splenic) reaches to the level of the twelfth thoracic spine, or the tenth rib posteriorly (this is the highest point reached by any part of the colon and lies about 5 in. above the level of the left iliac crest). Viewed from behind the large intestine on both sides overlaps the lateral borders of the kidneys and lies parallel to the lateral border of the sacrospinalis muscle. The transverse mesocolon has been extensively studied elsewhere (abdominal watersheds p. 141); and it was pointed out that this great transverse barrier separates the peritoneal cavity into two major divisions, supracolic and infracolic; that its root bisects the loop of the duodenum; that it has a slight obliquity upward from right to left; that this structure aids in forming the floor of the omental bursa or lesser peritoneal cavity, and other details of practical moment were discussed (Fig. 113).

The arrangement of the colic attachments, then, as usually found by the operator is as follows: more or less completely fixed are cecum, ascending colon, right (hepatic) flexure, left (splenic) flexure, descending colon, iliac colon, (and rectum); uniformly supplied with mesenteries are transverse colon and pelvic colon. At times the colic fusions with parietal wall do not continue to completion and quite commonly one encounters a mesocecum (cecum mobile), and some degree of ascending mesocolon will be found in 26 per cent of adults while some form of descending mesocolon may be expected in 36 per cent of cases.<sup>149</sup>

When mobilizing the ascending colon as for the removal of a growth (neoplasm; ileocecal tuberculosis) the attack upon the colon is best begun from the lateral rather than from the median border.<sup>150</sup> When the parietal peritoneum has been incised to the right of the ascending colon, this structure may be lifted from its bed by dry or blunt dissection, re-creating, in a sense, an ascending mesocolon or dorsal mesentery with

The Re-Creation  
of Mesenteries

its midline attachment, and the vessels may be cut, clamped and ligated, *secundum artem*, under full vision and safe control (Fig. 114). By this method the ureter is safeguarded



FIG. 114. Division of parietal peritoneum with mobilization of cecum and colon. (Rankin and Scholl).

as well. In a similar fashion the descending colon is best mobilized by working toward the midline from the lateral margin of the bowel. So relatively easy and safe is this approach that to any who have employed it the wisdom of regarding the

gastrointestinal tract as still basically a midline structure must be obvious.

*b. Attachment of Small Intestine.* Except for the duodenum the entire small intestine (20 ft.) is attached to the abdominal wall along a straight line but 6 in. in length. The intestinal loops coil and twist freely throughout the abdomen, suspended from the posterior wall by a lamina of connective tissue covered on each side by peritoneum (the jejunoileal mesentery or mesentery proper). The root of the mesentery follows an oblique line from the duodenojejunal junction (left side of second lumbar vertebra) to the right iliac fossa. In its oblique course it overlies the aorta, inferior vena cava, right ureter, and right psoas major muscle (see Fig. 112). The word mesentery (Gr. *mesos*, middle + *enteron*, intestine) properly signifies that this great encircling fold or double layer of peritoneum supplies small bowel only. The mesentery is not in reality fan-shaped as it is often described, for although the long free border is enormously frilled out the indentations and waves do not reach to the mesenteric root which is quite smooth. To construct a model of the structure, using non-organic materials to obtain the proportionate inequality between free-and root-borders would indeed tax the ingenuity. Winslow aptly compared the mesentery to a chamois, one border of which had been teased or thinned out while the other retained its full thickness; the one margin being flat, the other irregular, waved and elongated.<sup>151</sup>

The direction, course, length and arrangement of this final attachment of small intestine are determined quite largely by the superior mesenteric artery which in the adult is found to traverse the mesenteric root. It will be recalled that during intestinal rotation the only attachment of small bowel to parietes is located at the duodenocolic isthmus and that rotation takes place about the superior mesenteric artery as an axis, large intestine coming to overlie small intestine. As the ascending colon and cecum subsequently become fixed, by adhering to the mesoderm of the developing posterior



abdominal wall, so also does the superior mesenteric artery becomes attached to those structures which it overlies (aorta, right ureter, vena cava, right psoas major muscle); hence the

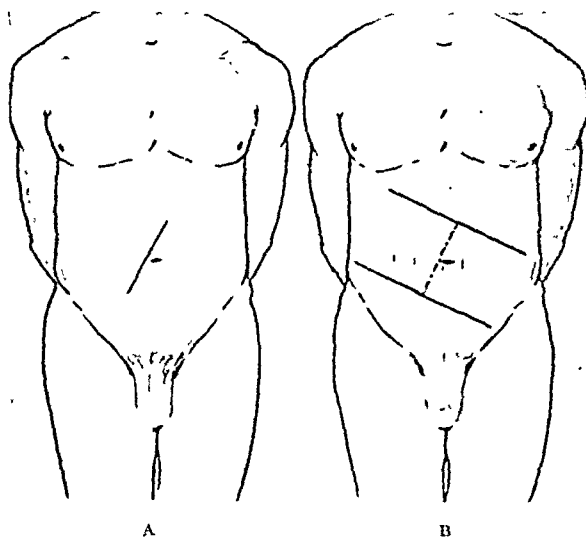


FIG. 115.

A. Showing approximately the line of the mesenteric root as traced on the abdominal wall.

B. Two oblique lines (black) drawn at right angles to the two ends of line (dotted) of the mesenteric root. The upper, middle and lower compartments, here indicated, contain in most instances the upper, middle, and lower thirds of the small intestine respectively. (From Monks.)

small bowel (jejunum and ileum) receives its new and final attachment to the parietes along the oblique line described by and representing the course of the artery. (See Fig. 112; repeat process with models; see p. 298.)

The course taken by the mesenterium or mesentery as mapped out upon the anterior surface of the abdominal wall is shown in Figure 115. A study of the attachment of the bowel makes it clear that although individual loops are free to move from side to side and for a limited range also upward and downward, yet they necessarily adhere to a relatively constant general position. And it has been repeatedly shown through tagging or marking individual loops that even though these be mechanically displaced or pushed about they will soon

Replacement of  
Intestinal Loops  
after Operations

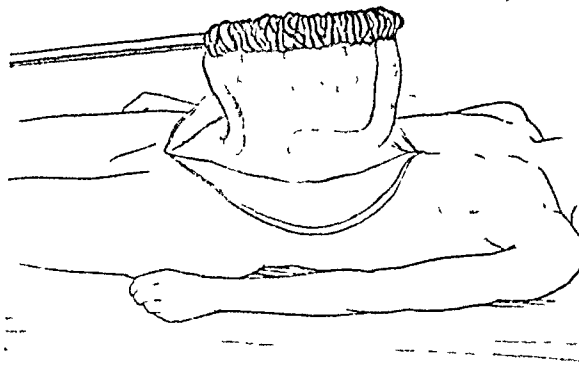
spontaneously rearrange themselves within the abdomen. Thus the surgeon need not attempt to replace the intestinal loops to their normal positions (a task which might prove puzzling or even impossible) after he has moved them about during an abdominal operation. It is asserted that only rarely will a loop of the lowest point of the small bowel be encountered high in the abdomen or a high loop be found near the pubis or pelvis. The only loop in which both position and direction are absolutely constant however is the proximal jejunum, which passes downward and to the left from the duodenojejunal juncture to the left of the second lumbar vertebra.

Both diagnostician and operator are greatly aided by knowledge as to what part of the bowel is most likely to lie beneath a given site on the body surface. Monks states<sup>152</sup> that "in a general way it may be said the uppermost third of the intestine usually occupies the large cavity on the left side of the abdomen, high up under the ribs; the middle third occupies the middle third of the abdomen and the left iliac fossa; and the lowest third helps to fill the pelvis and right iliac fossa." To mark upon the body wall these three areas or bowel zones, two oblique lines are drawn at right angles to the two ends of the mesenteric root as this is traced upon the anterior abdominal wall.

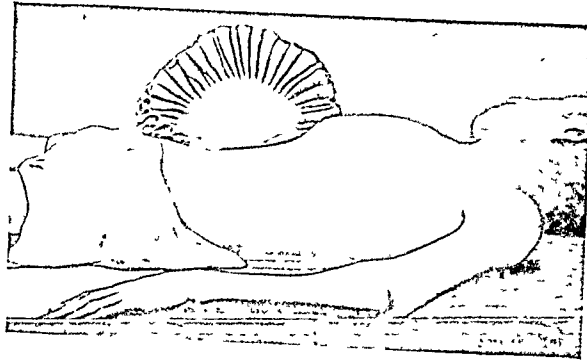
The Three  
Topographical  
Intestinal Zones

Monks suggests an excellent method in which to study the connections between intestine and posterior abdominal wall. This is as follows: Make a small hole in the ileum a few inches proximal to the ileocecal valve; push a stout glass rod about a foot in length into the intestinal lumen through this small hole; gradually thread the glass rod through the intestinal loop (i.e., gather the intestines together upon this rod); then it will be found that without undue force the entire 21 ft. of small intestine may be readily gathered together over the rod, forming a linear mass about 1 ft., in length; now place the rod with its intestinal contents in the line of the mesenteric root and the mesentery may be studied at will (Fig. 116A).

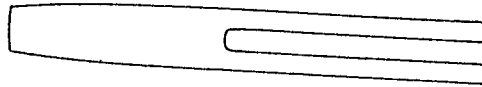
Methods for  
Study of the  
Mesentery



A



B



C

FIG. 116.

A. The small intestine is puckered upon a rod. It is surprising with what ease this can be accomplished. The rod cannot be pushed into the bowel, but the bowel can be drawn, loop by loop, over the end of the rod and "puckered" upon it, so that the various loops become packed together. In some later experiments occasionally a tube was used instead of a rod. (Drawn from a photograph.)

B. The intestinal tube has been thrown into alternate curves which are held in place by means of a stout copper wire within the gut. The alternating arrangement of the loops is most evident near the lower end of the ileum. The mesentery is a flapup to the place where the ruffled edge begins. (Drawn with slight modifications, from a photograph.)

C. The elevation of all the coils of the small intestine upon an instrument especially designed for this purpose.

(From Monks, *Surg. Gynec. Obst.*)

A practical advantage from being thus able to pass a short rod throughout loop after loop of small bowel immediately suggests itself. In acute intestinal obstruction when the intes-

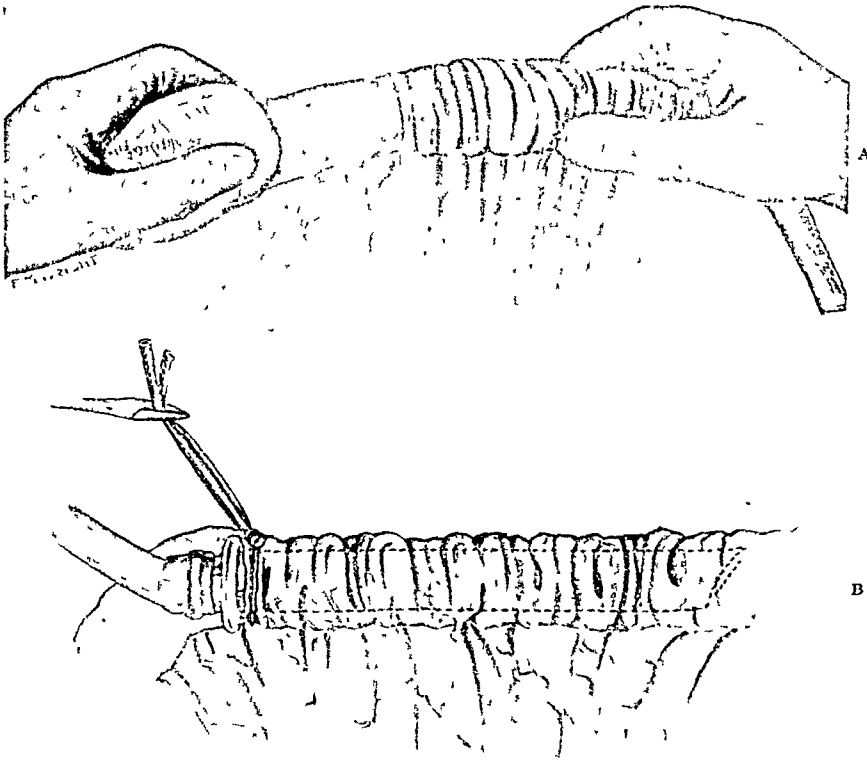


FIG. 117. Suction drainage of bowel in intestinal obstruction.

A. Bowel being pushed gently along tube.

B. Position of tube when as much of the gut as possible has been drained by it.

(From Moynihan's Abdominal Operations, Saunders.)

tine cephalad to the obstruction is greatly distended with highly toxic material or when the ballooning of the bowel is so great as to interfere materially with the necessary exploration it is possible to drain many individual loops by introducing a suction device into the intestinal lumen through a single small opening. It is found that in operating 6 to 8 or more feet of bowel can easily be reached by a tube 6 inches in length (Fig. 117). It is important that the bowel be threaded onto the rod

Draining the  
Bowel in Acute  
Intestinal  
Obstruction

rather than an attempt made to force the rod into the bowel.<sup>153</sup> Gentleness is obviously requisite. The maneuver is facilitated by holding the gut, as it is being coaxed onto the suction tube, by means of a piece of moist gauze. When as much intestine has been carried onto the tube as is convenient, additional loops may be emptied as the assistant gently milks the distended coils in the direction of the sucker. If the opening thus made in bowel is carefully repaired with through-and-through (locked; Connell) and seroserous (Lembert; Cushing) sutures the slight peritoneal contamination which may occur need not be particularly dreaded for the peritoneum is very resistant against colon bacilli unless the contamination be continuous or overwhelming. The maneuver (enterotomy) facilitates the exploration tremendously and the wisdom in draining the bowel of its toxic contents in acute obstruction is well established; this drainage is, in fact, almost an essential feature of such an operation; the measure has been repeatedly employed with impunity and often proves life-saving. The statement has previously been made that "no operation for acute intestinal obstruction can be considered complete which leaves an intestine, whose function it is to absorb, overdistended by contents of an offensive and poisonous nature."

A second method suggested for studying the mesentery, (Fig. 116B) is to thread a heavy wire through the intestinal lumen, in place of using a glass rod, and by kinking the wire, first to the right then to the left, again and again, to throw the entire jejunoileum into a series of short loops which center over the line of the mesenteric root and which may be readily handled or moved from side to side in examining the mesentery. A third method (Fig. 116C) and one which does away with the necessity for opening the intestinal lumen during the study, is to apply one blade of a large (1 ft.) fork to each side of the mesenteric root, and by lifting the fork anteriorly, to gather the intestinal coils into a linear mass above the prongs, exposing the bulk of the mesentery below. By moving the clustered bowels and extremity of the mesentery toward

Examining the  
Mesenterium

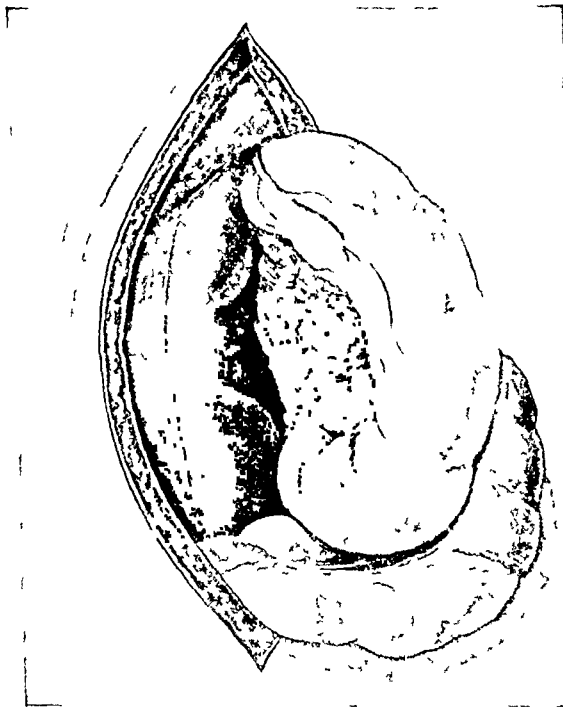
the right, one entirely exposes the left lower abdominal quadrant; while moving them to the left, one makes the right lower quadrant, ready for examination. The mesentery is seen to serve as a large oblique partition separating the two abdominal fossae; it is thick and smooth at its base and consists of a series of waves or ruffles in the outer third or fourth (free border); the intestine is suspended as on a hinge.

Between the two layers of mesentery are (a), the intestine, (b) extraperitoneal fat, areolar and fibrous tissue and a few smooth muscle fibers, (c) the mesenteric lymph glands (40 to 150 in number), (d) the mesenteric nerve plexuses and lymph vessels, (e) the jejunal and ileal branches of the superior mesenteric vessels. Embryologically considered the real root of the mesentery is the duodenocolic isthmus or that point where the vessels enter (see rotation and development of bowel). The thickness and opacity of the mesentery vary and as a rule the structure is more translucent at its upper end while the fat and consequent opacity increase markedly as the lower end is approached. This observation has some value for the surgeon as it aids him in orienting himself and in identifying the loops of jejunum and ileum as they are handled.

*c. Attachments of the Duodenum.* These have already been alluded to and may be summarized as follows: the duodenum, which was originally suspended from the median plane of the posterior abdominal wall (primitive mesoduodenum) is forced backward against the posterior wall by the transverse colon after rotation of the bowel has taken place. The duodenum, then, becomes adherent to the posterior parietes and is henceforth considered as a retroperitoneal or partially retroperitoneal structure. Reference has repeatedly been made to the duodenojejunal angle or junction of duodenum with jejunum. The attachments to the proximal duodenum of the lesser omentum (hepatoduodenal ligament) and of the right extremity of the gastocolic ligament (see duodenocolic ligament) will be dealt with as the attachments of the stomach are reviewed.



A



B

FIG. 118. Duodenal mobilization to expose retroperitoneal portion of common bile duct. (A from Taylor's Operative Surgery; Wood. B from Moynihan's Abdominal Operations, Saunders.)

There are times when it is desirable or necessary to mobilize the duodenum, for example, as a preliminary measure to the performance of a gastroduodenostomy or in order to gain access to the terminal (retroduodenal) portion of the common bile duct, or the head of the pancreas.<sup>154</sup> Here, as elsewhere, it should be recalled that the enteric canal is basically and originally a midline derivative. The mobilization may be safely effected as follows: incise the peritoneum vertically 1 in. lateral to the descending portion of the duodenal loop, that is, over the right kidney; by blunt dissection displace the entire duodenal loop medially (toward the left), re-establishing as it were the primitive median plane attachment; make sufficient traction toward the left to expose the posterior surface of duodenum and the head of the pancreas with its contained terminal portion of the common bile duct (Fig. 118).

The work of the diagnostician, no less than that of the operator, as following illustrative points tend to demonstrate, is rendered both more simple and accurate through acquaintance with details concerning gastrointestinal development and final anatomical arrangements.

Mobilizing the  
Duodenum

Exposure of  
Terminal  
Common  
Bile Duct



## EPONYM

JOSEF THOMAYER (1853-1927)\*

Eponym  
tion:

Defini- Thomayer's sign—a means of distinguishing inflammatory from non-inflammatory ascites. In inflammatory conditions of the peritoneum (malignant peritonitis, tuberculous peritonitis) the mesentery contracts, drawing the intestines over to the right side; consequently, when the patient lies on his back, tympany is elicited on the right side, dullness on the left.

CONTRIBUTION TO THE DIAGNOSIS OF TUBERCULOUS AND CARCINOMATOUS LESIONS  
OF THE PERITONEUM†

DR. JOSEPH THOMAYER

The clinical diagnosis of tuberculous and carcinomatous peritonitis is by some considered as difficult, by others as easy, a circumstance the obvious explanation of which is the type of cases the one or the other has for investigation. Undoubtedly the diagnosis of both named affections can be very easy. In dealing, for example, with a patient who has a palpable cancer of the stomach, when in the course of the affection distinct secondary nodules develop in the abdomen, and when in addition the abdomen begins to fill with fluid, the examining physician arrives at the correct diagnosis without necessarily being particularly clever. The same may be said of cases where besides a marked pulmonary tuberculosis a free ascites develops with severe lower abdominal pain, unassociated with disease of the liver, kidney, or heart.

Yet circumstances differ when we have before us a patient who exhibits all symptoms of marked ascites but with whom nevertheless the results of investigations regarding other organs and tissue remain negative.

We know that tuberculous peritonitis can be associated with isolated tuberculous mesenteric lymph glands or tuberculosis of the urogenital system or insignificant pulmonary involvement and marked intestinal tuberculosis; in short in a number of cases which present on the whole typical peritoneal involvement without the cause being readily diagnosed. I think only of genuine cases of tuberculous peritonitis, not of those which present numerous miliary nodules without further inflammatory changes of the peritoneum. For such cases offer even the experienced clinician many diagnostic difficulties . . .

I believe that the configuration of intestinal tympanites and its localization upon the abdominal walls often differs in both diseases discussed (carcinoma and tuberculosis of the peritoneum) from that usually seen with free ascites (non-inflammatory conditions) . . .

In all our cases of peritoneal carcinoma the mesentery had shrunk and in consequence the intestines were pulled up in a packet . . .

We know that the mesenteric root starts at the lumbar spine and proceeds obliquely from the second lumbar vertebra to the (right) sacroiliac symphysis. On the basis of these conditions it is self evident why the mass of loops of small intestine is displaced more to the right, especially in scirrhus carcinoma. In this disease the mesentery frequently shrinks considerably, subsequently the packet of small intestine must follow the shrunken fold and since this has its root on the right the small intestine must be found more in the right than in the left abdomen, provided such displacement is not prevented by special conditions . . .

\* A sketch of the life of Thomayer will appear when this material is published in book form.

† Translated from the original German.

# ZEITSCHRIFT FÜR KLINISCHE MEDICIN.

HERAUSGEGEBEN

VON

Dr. FR. TH. v. FRERICHS, und Dr. E. LEYDEN,  
*Professor der 1. medicinischen Klinik* *Professor der 2. medicinischen Klinik*  
IN BERLIN,  
Dr. H. v. BAMBERGER, und Dr. H. NOTHNAGEL,  
*Professor der 2. medicinischen Klinik* *Professor der 1. medicinischen Klinik*  
IN WIEN.

Siebenter Band.

Mit 10 lithographirten Tafeln.

BERLIN 1884.  
VERLAG VON AUGUST HIRSCHWALD.  
N.W. UNTER DEN LINDEN 64.

A

B

FIG. 119.

A. Facsimile of title page of journal in which original article by Thomayer appeared.  
B. Figures reprinted from article.

Upper left. Typical non-inflammatory ascites.  
Upper right. Malignant peritonitis secondary to carcinoma of ovary.  
Lower left. Malignant peritonitis secondary to carcinoma of stomach.  
Lower right. Tuberculous peritonitis.  
Shaded area—area of percussion dullness.  
Clear area—area of tympany upon percussion.  
Note that with non-inflammatory ascites the area of tympany is central in location while the dullness (fluid) is peripheral, a concave line marking the union of tympany with dullness. (upper left.)  
Note that with malignant and tuberculous peritonitis (inflammatory ascites) the tympany is found to the right side of the abdomen and along the line of the root of the mesentery while the dullness lies to the left, extending high in the left flank. (Upper right, lower left and right.)

## XIX.

### Beitrag zur Diagnose der tuberculösen und carcinomatösen Erkrankungen des Bauchfells.

• Doc. Dr. Josef Thomayer (Prag)

Die klinische Diagnose der tuberculösen und carcinomatösen Peritonitis wird von Manchen als schwierig, von Anderen dagegen als leicht dargestellt, ein Umstand, der offenbar davon abhängig ist, was für Fälle die Einen oder die Anderen zu untersuchen hatten. Denn es ist zweifellos, dass die Diagnose beider genannten Affectionen sehr leicht sein kann. Wenn sich z. B. bei einem Kranken, der an einem tastbaren Magenkarzinom leidet, im Laufe dieser Affection in der Bauchhöhle deutliche secundäre Knoten entwickeln, wenn nebenbei die Bauchhöhle sich mit Flüssigkeitserguss zu füllen beginnt, so braucht der untersuchende Arzt gewiss keineswegs besonders scharfsinnig zu sein, um die richtige Diagnose zu stellen. Das Gleiche gilt von Fällen, in denen neben ausgesprochener Lungentuberculose unter heftigen Unterleibsschmerzen ein freier Ascites sich entwickelt, ohne dass eine Leber- oder Nieren- oder Herzerkrankung anzunehmen wäre.

Anderes verhalten sich jedoch die Umstände, wenn wir einen Kranken zu behandeln haben, der zwar alle Erscheinungen von hochgradigem Ascites darbietet, bei dem jedoch sowohl local, als in den übrigen Organen und Geweben das Untersuchungsergebnis negativ bleibt.

Denn tuberculöse Peritonitis kann sich bekanntermassen entwickeln neben isolirter Tuberculose der Mesenterialdrüsen, neben occulter Tuberculose des Urogenitalapparates<sup>1)</sup>, neben unbedeutender Lungenaffection

und bedeutend entwickelter Darmtuberculose, kurz in einer ganzen Reihe von Fällen, in denen es sich zwar um eine im Ganzen typische Affection des Peritoneums handelt, ohne dass die Diagnose gar so leicht zu stellen wäre. Hierbei habe ich nur Fälle von wirklicher tuberculöser Peritonitis vor den Augen, und berücksichtige nicht solche, in denen zahllose miliare Knotchen ohne weitere entzündliche Veränderungen am Peritoneum vorgefunden werden. Denn solche Fälle bieten selbst dem erfahrensten Kliniker wohl manche diagnostische Schwierigkeiten.

<sup>5</sup> Ich glaube nämlich, dass die Contouren des tympanitischen Darm-schalles sowie auch ihre Localisation an den Bauchdecken bei beiden in Frage stehenden Affectionen mitunter eine andere ist als es bei freier Ascitesflüssigkeit gewöhnlich der Fall ist.

In allen unseren Fällen von Carcinom des Peritoneums war das Mesenterium geschrumpft und die Gedärme in Folge dessen zu einem Knäuel zusammengeballt.

Wir wissen ja, dass<sup>9</sup> der Radix mesenterii an der Lendenwirbelsäule beginnt und in schiefer Richtung vom zweiten Lendenwurm zur rechtsseitigen Symphysis sacroiliaca verläuft. Auf Grund dieser Verhältnisse ist es von selbst einleuchtend, warum speciell bei skirrösen Krebsformen der Dunndarmknäuel mehr nach der rechten Seite verschoben wird. Das Mesenterium schrumpft aber bei dieser Krankheitsform häufig in ausserordentlichem Masse, in Folge dessen muss der Dunndarmknäuel dem schrumpfenden Gekröse folgen, und da dieses rechtsseits seinen Ursprung hat, so muss auch dann der Dünndarm mehr in der rechten als in der linken Hälfte vorgefunden werden, vorausgesetzt dass ihn besondere Verhältnisse an einer derartigen Verschiebung nicht hindern.

<sup>8</sup> Auf Grund dieser Verhältnisse ist es mir klar, dass unter solchen Umständen das Percussionsresultat ein wesentlich anderes ist, als bei gewöhnlichem freiem Ascites.

Die vorgehenden Auseinandersetzungen betreffen zwar nur das Carcinom des Bauchfells, doch gilt für die Tuberculose mutatis mutandis dasselbe. Denn auch bei der sogenannten tuberculösen Peritonitis kommen schrumpfende Processen sowohl im Omentum als im Mesenterium vor, wodurch dann die Dunndarmschlingen ein ähnliches Schicksal erfahren wie beim Carcinom. Deswegen sind auch die die Percussionsverhältnisse zur Anschauung bringenden Schemata einander sehr ähnlich und bei beiden Krankheiten analog. Möglicherweise geschieht die Schrumpfung des Gekröses bei Tuberculose nicht in so intensiver Weise wie beim Carcinom, die eben in den schematischen Zeichnungen der Darm-schall nicht so rechtsseits vorwiegt wie bei den Carcinomen, doch besitze ich hierüber keine Erfahrungen.

Es ist schwer bestimmbar, warum derartige Fälle nicht schon längst eine neue genauere Durcharbeitung der Percussionsverhältnisse bei Ascites veranlasst haben, doch scheint es, dass die Ursache in folgenden Umständen zu suchen ist. Ein Practiker wendet Percussion bei einem Ascites wohl zuletzt an, früher sucht er sich durch andere Untersuchungsmethoden den Aufschluss zu verschaffen und percutirt wohl zumeist, wenn er mit seiner Diagnose im klaren ist. Denn auch in der Klinik werden in ähnlichen Fällen Palpation, chemische, mikroskopische Untersuchungen, Probepunctionen etc. viel mehr geübt, als die simple Percussion des Unterleibes, die wohl nur in Cursum für Anfänger genauere Berücksichtigung findet. Dasselbe geschieht auch in der Praxis, und es ist dies nur zu bedauern, weil die klassische physikalische Untersuchung leicht ist und überall angewendet werden kann.

Halten wir uns vor den Augen, dass das schrumpfende Gekröse den Dunndarmknäuel nach der rechten Seite zu ziehen die Tendenz hat, so werden wir in speciellen Fällen mit unserer Diagnose vorsichtig sein.

FIG. 19C. Facsimile of excerpts from original article by Thomayer.

These conditions make it plain that the result of percussion is essentially different from that found with ordinary free ascites . . .

These explanations concern carcinoma of the peritoneum yet they hold good also for tuberculosis. For even so-called tuberculous peritonitis presents shrinking of the omentum as well as the mesentery, which causes similar conditions for the loops of small intestines as in carcinoma. Therefore the diagrams illustrating percussion conditions are very similar and analogous in both conditions. Probably mesenteric shrinkage with tuberculosis is not as intensive as in carcinoma for the diagrams do not show that tympanites predominates as much on the right as in carcinoma, yet I have no observations on that fact . . .

It is rather difficult to understand why in such cases percussion conditions in ascites have not long ago caused more exact revision but probably the cause is the following: the practical physician tends to use percussion as the last resort in ascites and tries to base his diagnosis first on other methods of examination, using percussion only when in doubt about diagnosis. In the clinic also in similar cases palpation, chemical and microscopic tests, exploratory puncture, etc. are used rather than simple percussion of the abdomen which is used only in courses for beginners. The same thing happens in practice and it is much to be regretted for the classical physical examination is easy and is applicable in every case . . .

If we remember that the shrinking mesentery tends to displace the mass of small intestines toward the right we shall be more careful in diagnosing individual cases . . .

#### QUESTIONNAIRE

1. Describe the development of the peritoneal cavity.
2. From what germ layer does peritoneum arise?
3. What is the splanchnic mesoderm; the somatic mesoderm; endothelium?
4. Give derivation of the words splanchnic, somatic.
5. What is the primitive dorsal mesentery; its relation to the mesenteries omenta and peritoneal folds in the adult?
6. Describe the attachments between liver and stomach; between stomach and colon; between liver and anterior abdominal wall.
7. Why are the falciform ligament and lesser omentum at right angles to one another?
8. Explain why some portions of the gastrointestinal tube are firmly adherent to the parietics while others are freely movable?
9. Explain how the jejunum and ileum become attached to the posterior abdominal wall by a six inch mesentery?
10. How does the superior mesenteric artery come to cross the terminal portion of the duodenum?
11. Why does the root of the transverse mesocolon overlie the duodenum rather than is attached directly to the abdominal wall?
12. Give some differences in appearance between a sarcomatous ulcer and a carcinomatous ulcer?
13. Give a clinical differentiation between a desmoid and an epithelioma of the abdominal wall.
14. Which are more common within the abdomen, benign or malignant newgrowths?
15. What is the relative frequency of primary and of secondary neoplasms within the peritoneal membrane?
16. State most common sites from which secondary malignant peritoneal newgrowths arise.
17. From what retroperitoneal tissues do newgrowths arise?

18. How may retroperitoneal newgrowths be differentiated from those arising from peritoneum?
19. From what cells do primary malignancies of peritoneum originate?
20. Discuss some of the names given to primary newgrowths of peritoneum.
21. Describe the gross pathology of primary peritoneal malignancies.
22. What conditions do these newgrowths simulate? Give differential diagnosis.
23. What are the most common causes of bloody peritoneal fluid?
24. Discuss the prognosis and treatment for primary peritoneal malignancies.
25. Give a list of intra-abdominal tissues arising from the three embryonic germinal layers.
26. What part does each germ layer play in the formation of bowel, liver, spleen, pancreas?
27. What are chromaffin bodies? What is their histogenesis?
28. State the similarities between chromaffin system and sympathetic nervous system.
29. In what ways does a knowledge of the germinal origin of tissues aid the clinician?
30. Why should the practical surgeon review the germinal origins of the tissues with which he deals?
31. Why is the left vagus distributed to the anterior wall of the stomach?
32. Describe the embryonic rotation of the stomach.
33. What are the anatomical divisions of the duodenum? Describe each.
34. Describe the relation of the root of the transverse mesocolon to the duodenum.
35. What is the most frequent site for duodenal ulcers?
36. What is the value of roentgen-ray examination for peptic ulcer?
37. Why is it correct to refer to a duodenal ulcer as a variety of peptic ulcer?
38. What is the duodenal cap? Describe in detail.
39. What are the roentgen-ray findings with duodenal ulcer?
40. Discuss the limitations of roentgen ray as a diagnostic aid in determining the presence of active peptic ulcers.
41. Do healed duodenal ulcers cause evidence of deformity of the duodenal cap?
42. What is the duodenojejunal angle? How produced?
43. Describe methods for locating the proximal jejunum.
44. What three peritoneal reflexions meet at the duodenojejunal junction?
45. Describe the location of the duodenojejunal junction.
46. Why does the proximal jejunum abruptly enter the abdomen from below the root of the transverse mesocolon?
47. What is the ligament of Treitz?
48. Describe the embryonic rotation of the intestines.
49. What is the duodenocolic isthmus?
50. What is meant by saying that intestinal rotation occurs upon the superior mesenteric artery as an axis?
51. Does the artery itself rotate during intestinal rotation?
52. Describe the effect upon the branches of the superior mesenteric artery of intestinal rotation.
53. Why does the appendix at one period of development come to be lodged below the liver?
54. What is meant by the embryonic position of the appendix?
55. Describe methods for studying the phenomenon of intestinal rotation by means of models.
56. What is meant by saying that the gastrointestinal tract always remains basically a midline structure?
57. What is meant by raw or uncovered areas of the abdomen?

58. What portions of colon are partially retroperitoneal and which are supplied by mesocolons? Explain these arrangements.
59. To what height is the right colic flexure fixed; the left colic flexure?
60. What is the omental bursa?
61. What is the relation of the transverse mesocolon to the omental bursa?
62. In what percentage of individuals may an ascending or descending mesocolon be expected?
63. Describe the mobilization of the cecum and ascending colon.
64. Describe the root of the mesentery as to length and position.
65. Describe the structure of the mesentery.
66. What is the relation between superior mesenteric artery and mesentery?
67. Map out the mesentery on the anterior abdominal wall.
68. What are the three intestinal topographical zones?
69. Describe methods for studying the mesentery.
70. How may the bowel be drained of its toxic contents during operations for acute intestinal obstructions?
71. What structures are found between the peritoneal layers of the mesentery?
72. Describe the attachments of the duodenum.
73. What is the hepatoduodenal ligament; the duodenocolic ligament?
74. When is it advisable to mobilize duodenum?
75. Describe a method for mobilization of the duodenum.

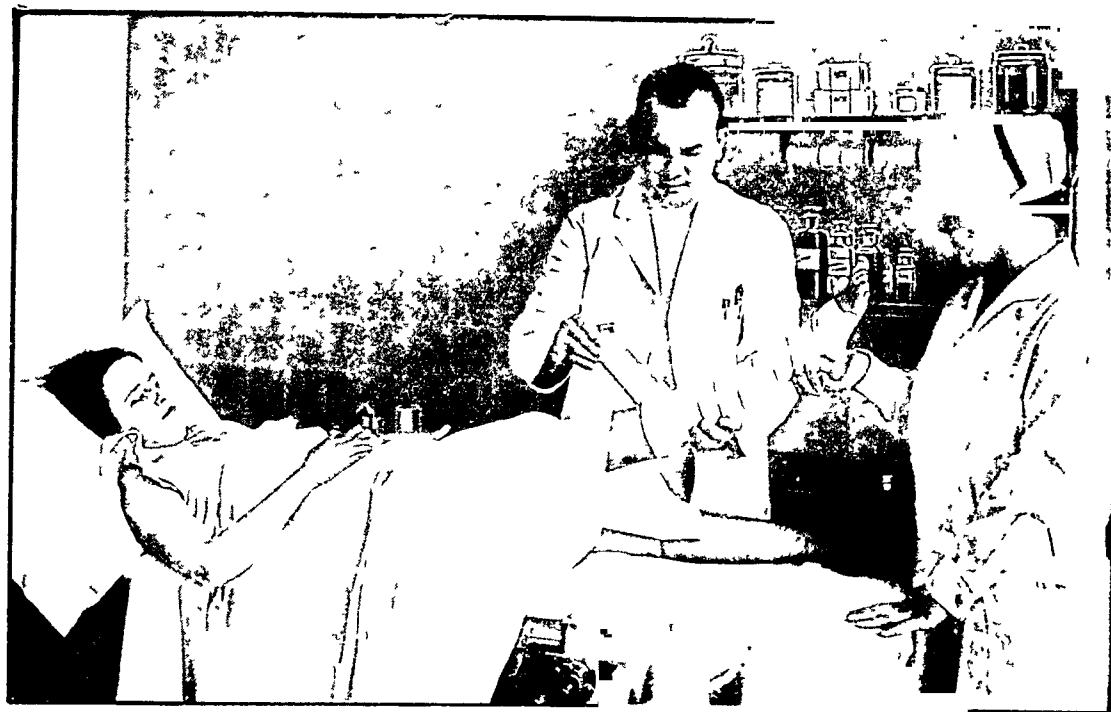
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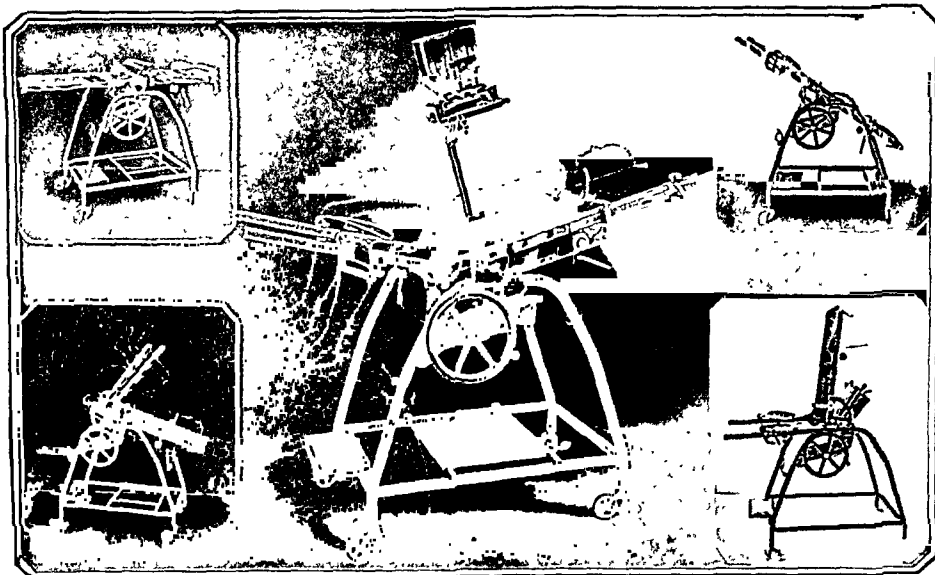
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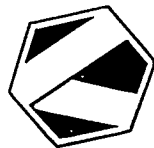
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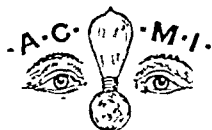
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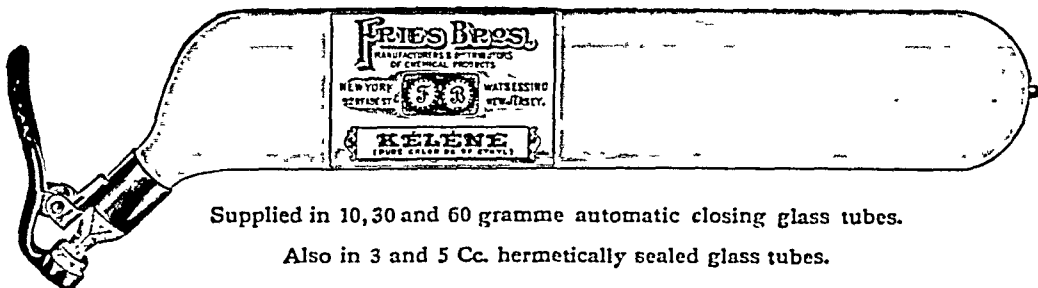
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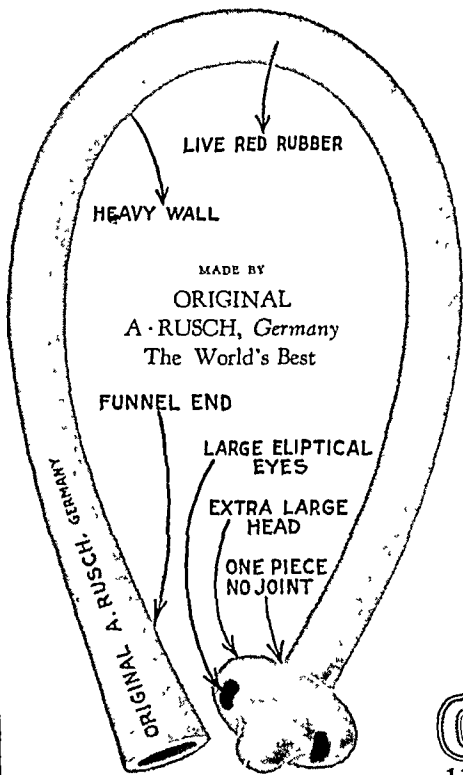
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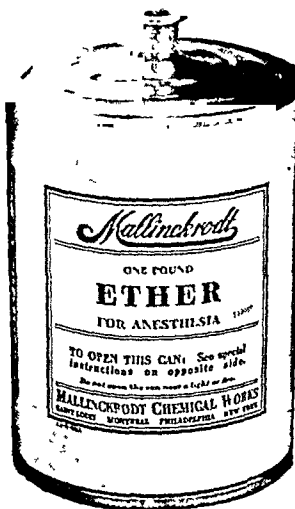
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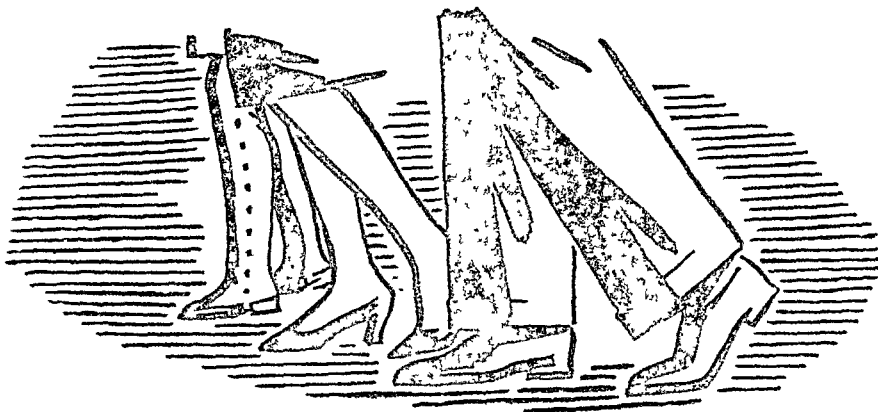
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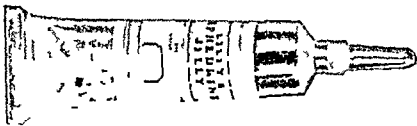
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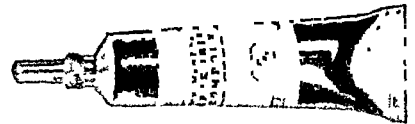
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**GERMICIDAL.** Exerts a bactericidal action in the suture tract. Supersedes the older unstable iodized sutures. Impregnated with the double iodine compound, potassium-mercuric-iodide.† Heat sterilized.



The boilable grade is unusually flexible for boilable catgut; the non-boilable grade is extremely flexible.

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1205.....	PLAIN CATGUT.....	1405
1225.....	10-DAY CHROMIC.....	1425
1245.....	20-DAY CHROMIC.....	1445
1285.....	40-DAY CHROMIC.....	1485

Sizes: 000..00..0..1..2..3..4

*Approximately 60 inches in each tube*

Package of 12 tubes of a size. ....\$3.00  
Less 20% on gross or more or \$28.80, net, a gross

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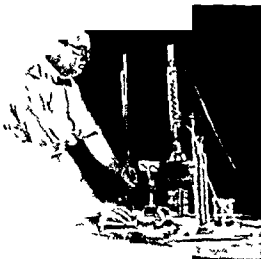


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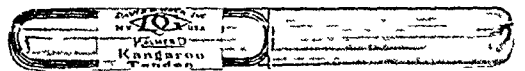
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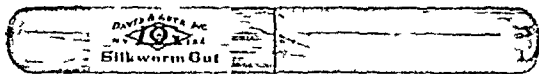
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360..HORSEHAIR.....	168.....	00
390..WHITE SILKWORM GUT..	84.....	00, 0, 1
400..BLACK SILKWORM GUT..	84.....	00, 0, 1
450..WHITE TWISTED SILK....	60.....	000 TO 3
460..BLACK TWISTED SILK....	60.....	000, 0, 2
480..WHITE BRAIDED SILK....	60.....	00, 0, 2, 4
490..BLACK BRAIDED SILK....	60.....	00, 1, 4

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812..10-DAY KALMERID "	20..00, 0, 1, 2, 3	
822..20-DAY KALMERID "	20..00, 0, 1, 2, 3	
862..HORSEHAIR .....	56.....	00
872..WHITE SILKWORM GUT...	28.....	0
882..WHITE TWISTED SILK....	20.....	000, 0, 2
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914..10-DAY KALMERID "	20..00, 0, 1, 2, 3	
924..20-DAY KALMERID "	20..00, 0, 1, 2, 3	
964..HORSEHAIR.....	56.....	00
974..WHITE SILKWORM GUT...	28.....	0
984..WHITE TWISTED SILK....	20.....	000, 0, 2

### BOILABLE

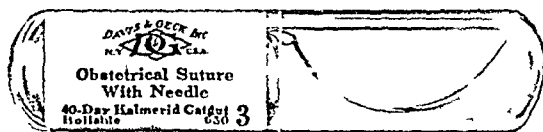
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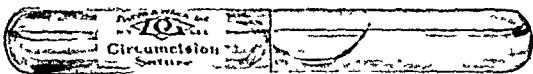
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## Universal Suture Sizes

All sutures are gauged by the standard catgut sizes as here shown

000	4
00	6
0	8
1	16
2	24
3	

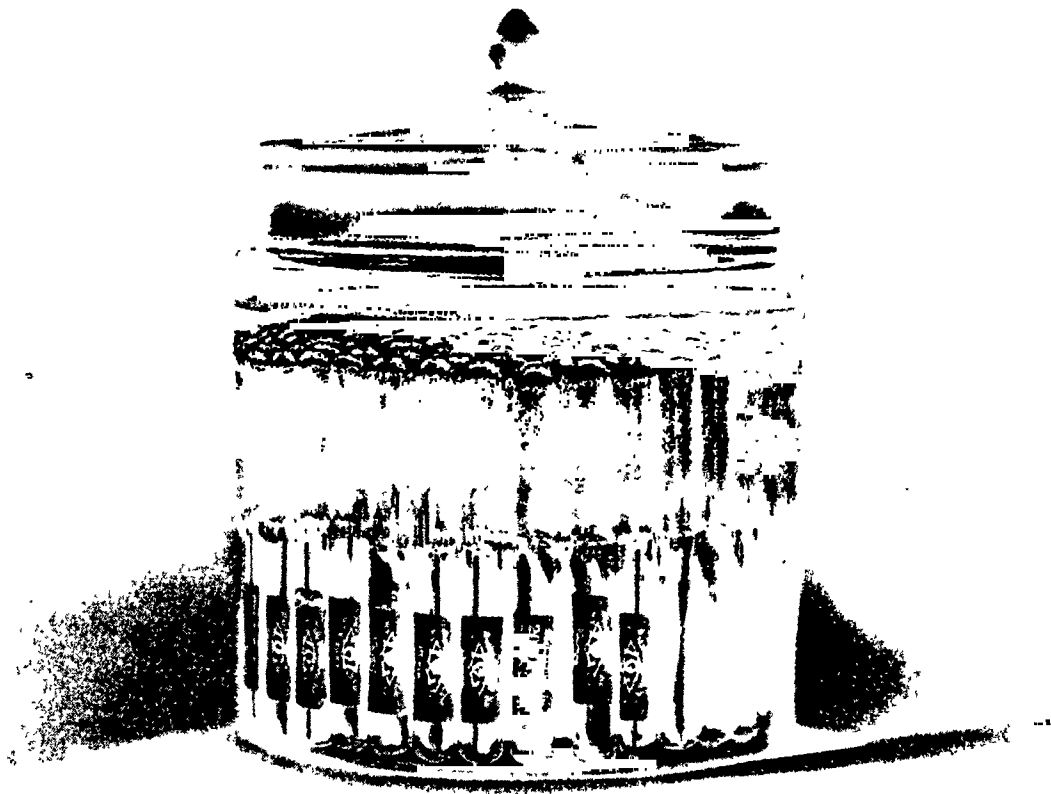
\*These tubes not only may be boiled but even may be autoclaved up to 30 pounds pressure, any number of times, without impairment of the sutures.

†Potassium-mercuric-iodide is the ideal bactericide for the preparation of germicidal sutures. It has a phenol coefficient of at least 1100; it is not precipitated by serum or other proteins; it is chemically stable—unlike iodine it does not break down under light and heat; it interferes in no way with the absorption of the sutures, and in the proportions used is free from irritating action on tissue.

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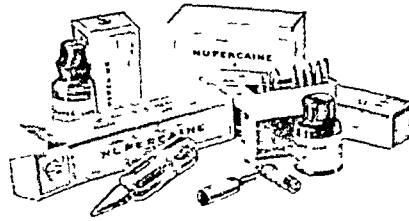
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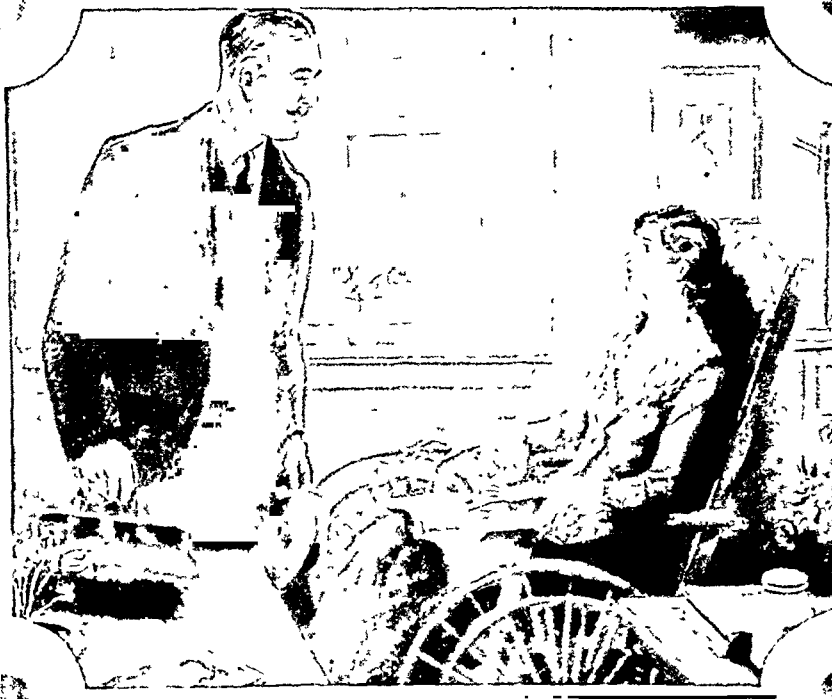
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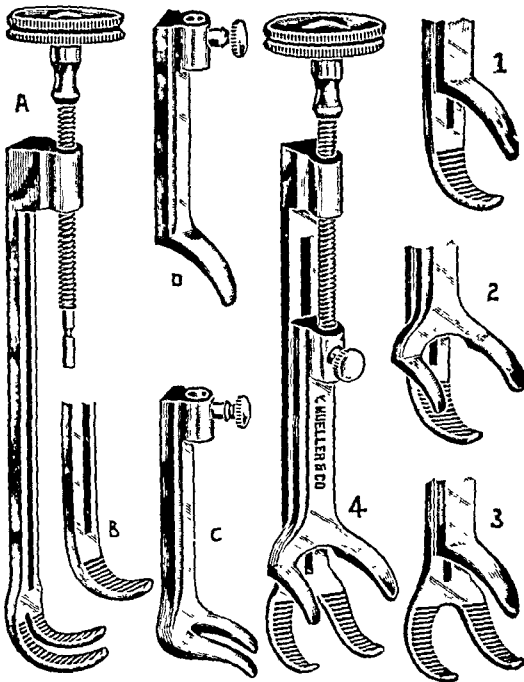
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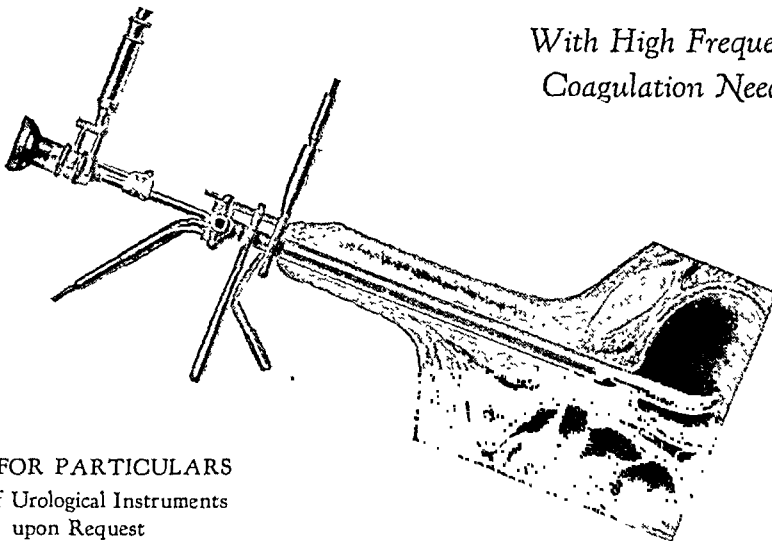
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# The American Journal of Surgery

NEW SERIES, VOL. IX

AUGUST, 1930

No. 2

## USE OF ELECTROSURGERY IN NEUROLOGICAL SURGERY\*

LOYAL DAVIS, M.D., PH.D., AND B. M. GROEN, R.N.

CHICAGO, ILL.

THE surgery of lesions of the central nervous system, particularly those situated within the intracranial cavity, calls upon the surgeon to meet a number of factors inherently difficult in the nature of the operative field. The dynamics of the cerebrospinal fluid, the lack of resistance which nerve tissue affords against infection, and the necessity for making both an accurate localizing and pathological diagnosis before operation, are but a few of the problems which must be controlled to achieve successful results in this field of surgery.

Here, as elsewhere in surgery, one of the great problems is to control and to diminish the effects of hemorrhage as far as is possible. Among the devices which have been developed toward these ends in the progress of neurological surgery may be mentioned the use of silver clips, of muscle implantations, of tissue fixation *in situ*, and if necessary the coincident or subsequent employment of blood transfusions or refusion with the patient's own blood which has been collected from the wound by a suction apparatus. Lately another principle, that of electrosurgery, has come to be employed not only as a means of perfecting hemostasis in intracranial operations in general but as a direct aid to the successful treatment of certain types of lesions.

In 1600, William Gilbert,<sup>1</sup> surgeon to Queen Elizabeth, published his great work

"De Magnete" and in it laid the foundation for the development of the use of electrical currents in medical science. In 1780, Galvani<sup>2</sup> accidentally discovered that muscular contractions could be produced by an electric current. Later this particular type of current was used in the development of the galvanocautery which produces a dissolution of tissue by chemical action. In 1888, Hertz<sup>3</sup> succeeded in producing a series of electric oscillations of a very high frequency. Shortly after this Tesla<sup>4</sup> produced heat within the tissues as a result of the passage of an electric current of high frequency. In the same year, D'Arsonval<sup>5</sup> stated that it was possible to pass a high frequency current of 3 amperes through the body with the production of no other sensation than that of heat. He found that a current which alternated less than fifteen times per second produced clonic muscular contractions, while one which alternated twenty or thirty times per second produced a tonic contraction. As the frequency increased to a maximum of about 300 oscillations per second the intensity of the tonic contraction increased. However, beyond this rate it became less intense until at a frequency of about 10,000 per second all muscular contractions ceased.

Shortly after this communication of D'Arsonval, attempts were made to employ electric energy in the form of high frequency currents upon neoplasms. Ful-

\* From the Laboratory of Surgical Research and the Department of Surgery, Northwestern University Medical School. Submitted for publication May 5, 1930.

guration or sparking was looked upon by early investigators as a possible and valuable factor in the destruction of neoplasms.

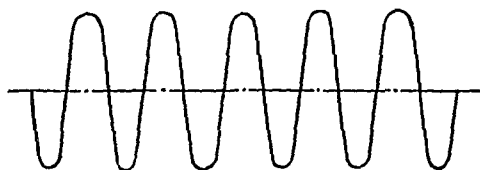


FIG. 1. Undamped wave which will cut but has very little dehydration effect.

The ever-present, although uncontrollable, long spark from the high voltage apparatus was recognized as a possible factor of great value in cauterizing and carbonizing malignant tumors. In 1907, Possi<sup>6</sup> reported the cure of superficial and even deep-seated carcinoma by the action of sparks from the terminal of an Oudin resonator. However, subsequent investigation has shown that fulguration merely raises the local temperature to an enormous height and carbonizes the neoplasm superficially, thereby defeating the very purpose it aims to attain. Deeper destruction of the neoplasm is thus prevented by protective carbonization which is produced by the spark. In 1908, Nagelschmidt<sup>7</sup> demonstrated a specially designed apparatus of high frequency, with lower voltage and improved resonance. The surgical application of this type of apparatus in the coagulation of malignant growths was introduced first by Doyen.<sup>8</sup>

To obtain a clear understanding of the field of electrosurgery, it is essential to understand clearly the terms found in the literature. Medical diathermy, for example, is that type of high frequency which will keep the heat within physiological limits, and which does not lead to damage of the tissue. On the other hand, surgical diathermy is the use of high frequency currents to produce cellular destruction proportional to the degree of heat created within the tissues. To avoid confusion in the use of these two terms, the word electrosurgery has been introduced by Cushing<sup>9</sup> to describe the use of surgical diathermy. Fulguration, electrolysis, gal-

vanocautery, Paquelin cautery and the Percy cautery differ from electrosurgery in that the heat is generated in the applica-



FIG. 2. Highly damped wave which will not cut but has excellent coagulation qualities.

tors themselves which are always hot when applied. The effect of these latter procedures is to cauterize or burn the tissue which under the conditions of neurological surgery is undesirable. In electrosurgery the heat is generated after the applicator has made contact with the tissues.

The currents applied for electrosurgical purposes must be of such high frequency that the electrical shocks, chemical action, molecular changes and lethal effects associated with ordinary commercial currents may be entirely absent. This means that the direction of the flow of current must be reversed at a rate of upwards of a million times per second. A variety of effects may be produced depending upon the type of tissue operated upon and the characteristic of the high frequency current used. In speaking of the character of a current we mean the frequency and type of alternations in the direction of the flow of current. The alternations of the current may be regular, or they may die out and then after an interval of time start in again, either suddenly or slowly. The regular current is referred to as "undamped" (Fig. 1) and the irregular as "damped" (Fig. 2). It will be noted that an undamped or continuous wave current flows with practically a continuous application of energy, substantially uniform in rate and amplitude. However, the fact that a current is of high frequency does not necessarily suit it to electrosurgery. Even though a pure undamped or continuous wave current has excellent cutting quali-

ties, it offers no advantages over the ordinary scalpel, because it has very little hemostatic effect upon the severed edges of the tissues. However if the active electrode is energized with a frequency current which has wave trains which lie between those of the undamped and highly damped current, tissues may be cut and at the same time the surfaces will be dehydrated (Fig. 3). Thus by variation of the amount of damping any degree of hemostasis can be obtained. Through this modification of the wave train the action of the current may be changed from free cutting without dehydration and coagulation, to coagulation and dehydration without cutting. It is therefore possible to modulate the current in accordance with the vascularity of the tissues which are to be incised.

In electrosurgery there are three distinct ways in which the high frequency current may be used: (1) dessication or dehydration, (2) cutting, (3) coagulation.

Electrodesiccation embraces the effect of drying or dehydration of the tissues. Histologically, the effect is what is to be expected from the application of a very mild dehydrating agency with the production of mummification. The cell outline is barely visible and because the water has been literally boiled out, the protoplasm is dried. The death of the cell is associated with very little degenerative change and with a small amount of necrotic material so that but a small amount of fibrous tissue is formed. To obtain this effect the active electrode is not in contact with the tissues. However, it is sufficiently close so that sparks are sprayed across the gap between the electrode and tissue. The temperature of these sparks is sufficiently high to produce superficial dehydration.

In neurological surgery, cutting with the electrosurgical current may be done with needles, small blunt blades, or loops made of wire. Sharpened blades are unnecessary because the electrode itself does not actually sever the tissues. This is accomplished by the current which forms an electrical arc ahead of the electrode.

The tissues are thus separated by volatilization as though they were cut. Depending upon the vascularity of the tissues,

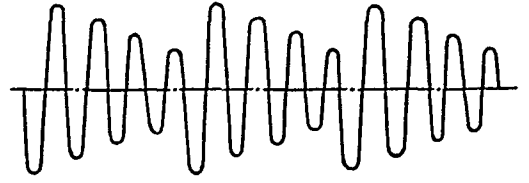


FIG. 3. Moderately damped wave which has excellent cutting qualities and gives a light degree of dehydration.

the cutting current may be damped proportionately to produce coagulation.

Histologically, electrocoagulation produces a complete cellular necrosis with a variable inflammatory reaction in the adjacent tissues. There is also produced thrombosis and hyalinization of the blood vessels, small round cell infiltration and fibrosis. When an electrode is energized by such a highly damped current, there is not the slightest indication of a cutting action. Instead the electrode is immobile. The mass or amount of coagulated tissue is governed by the power used and the length of time the current is applied. If heavy power is used and the current is applied for a short time a thin depth of coagulated tissue will result. If the current is of high power and is applied too long, it will tend to char and carbonize the tissue which under ordinary circumstances would be undesirable. To produce a heavy depth of coagulated tissue without carbonization, requires the application of a smaller amount of power over a relatively longer period of time. This type of current has a great many surgical uses other than the destruction of pathological tissue. It may be used in the sealing off of small and medium-sized blood vessels in the cortex of the brain, or on the surface of a meningioma. By picking up the vessel with the forceps, or hemostat, and then touching the instrument with the active electrode, it will be found that the vessel grasped will be coagulated. This may be done either before or after the vessel has been severed. By this means

the use of silver clips, while they are not dispensed with entirely, can be reduced to a minimum. It is obvious that the chief advantage of the electrosurgical current is the fact that its dehydrating powers can be varied at will.

Progress in the treatment of intracranial lesions can be traced along three lines: (1) accurate localization, (2) improved surgical technic and (3) pathological classification of the tumors encountered. At present, one must consider preoperatively not only the exact location of the lesion but there should be a rather definite idea of just which type of tumor may be uncovered. So it is that neurologic surgeons are speaking of the location and behavior of particular tumors rather than of intracranial tumors as a whole and the general effects of intracranial pressure. It is to the surgical treatment of certain of the intracranial tumors that electrosurgery lends itself and to Cushing belongs the credit of first using it in craniocerebral surgery.

It must not be assumed that the advent of electrosurgery has meant the abandonment of the principles of osteoplastic intracranial operations. It has meant only that the successful removal of certain tumors, both encapsulated and otherwise, has been advanced considerably and that a valuable addition has been made to the surgeon's armamentarium.

#### MENINGIOMAS

Meningiomas may vary in their gross appearance and microscopic structure yet they are all similar in their origin from the cells of the arachnoid. Some of them produce hyperostoses from invasion of the haversian canaliculi; some cause a pressure atrophy of bone, while others produce no bone change whatever. However, they have favored points of origin and in each instance produce symptoms which give rise to a recognizable syndrome. Some arise from the meninges over the surface of the cortex and form a globular tumor mass which may be removed with comparative

ease. Still another group arise from the olfactory groove, and others from the basilar meninges about the sella turcica. Other meningiomas may be attached to the falx cerebri; to the sphenoidal ridge lateral to the sella turcica; or other flat growths which spread over the meninges covering the anterior and lower part of the temporal lobe may produce no intracranial symptoms and yet are associated with a unilateral exophthalmos and marked thickening of the bone of the lateral wall of the orbit and the temporal fossa.

Because of their benign character the meningiomas are considered to be the most favorable group of intracranial tumors for surgical removal. However, they may attain an enormous size, often with invasion of the bone, before they are recognized. They are usually attached to the dura mater near the cranial sinuses and unless this point of origin is removed it is likely that the tumor will recur. Consequently they may be situated in locations very difficult of access. Even when they are more accessible, it may be necessary to ligate large sinuses, a step which may be followed by a train of mechanical circulatory disturbances. So it is that many times they are looked upon by the surgeon with a great deal of trepidation. The following case will serve to illustrate the use of electrosurgery in the surgical treatment of these tumors.

*Right primary optic atrophy. Left papilledema. Bilateral anosmia. Mental hebetude. First stage transfrontal osteoplastic flap. Second stage removal of olfactory groove meningioma. Recovery.*

Mrs. C. C., Wesley Memorial Hospital, No. 139448, aged fifty-one, was referred by Dr. F. C. Warne of Chicago, on July 20, 1928.

*History:* In 1920, the patient consulted an ophthalmologist who diagnosed an optic atrophy in the right eye. Nothing further was done about this until in 1927 she became listless, disinterested and unable to carry on her housework. Lately she had slept most of the time. There was no complaint of headache or vomiting.

*Examination:* The right pupil reacted only slightly to light but the left reacted promptly.

Vision was lost entirely in the right field and was diminished in the left with greater loss on the temporal side. There was a complete

obvious that the tumor could not be tilted out of its bed by traction sutures (Fig. 4). With the electrosurgical unit the tumor was incised and

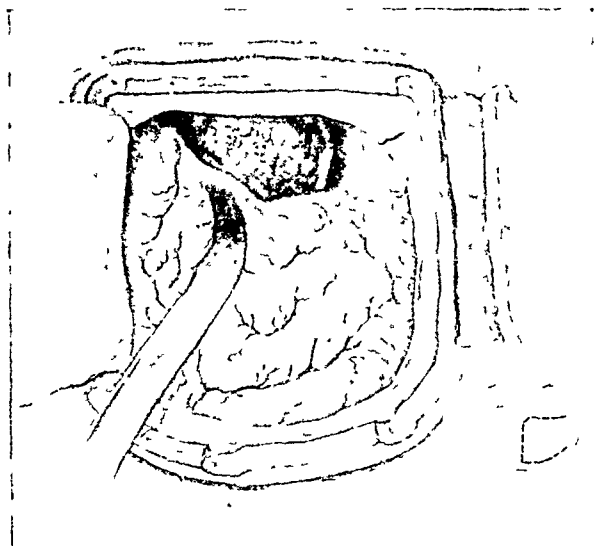


FIG. 4. Drawing elaborated from operative sketch which shows meningioma below frontal lobe.

primary optic atrophy in the right eye. The retinal veins of the left eye were engorged and there was a beginning papilledema. There was a bilateral loss of olfactory sense. Movements of the left hand were clumsier than the right. The left upper extremity fell away when held extended. Deep tendon reflexes in the left upper extremity were greater than on the right. X-ray examination of the skull showed a thickening of the floor of the right frontal fossa and an indistinct outline of the clinoid processes of the sella turcica.

**Diagnosis:** A preoperative diagnosis was made of a meningioma lying in the right frontal fossa. The syndrome of unilateral optic atrophy, anosmia and mental symptoms made it appear likely that the tumor originated from the olfactory groove.

**Operation:** Upon August 2, 1928, a right transfrontal osteoplastic flap was turned down under local anesthesia. There was considerable bleeding from the bone and scalp which was difficult to control. Therefore the flap was replaced without opening the dura mater and a second stage operation was decided upon.

On August 7, 1928, the tumor was exposed. It proved to be a large meningioma which occupied the right frontal fossa and extended beyond the median line to the left. It was attached about the olfactory groove. The frontal lobe was retracted upward and it was



FIG. 5. Patient on day of discharge from hospital. Note inconspicuous wound.

then the inside was looped out with the coagulating current. This was continued until the tumor had been entirely removed from the floor of the fossa. Successive attempts to tilt the capsule of the tumor by silk sutures met with failure. The tumor was therefore removed in scallops down to its attachment and this was sprayed with the current to kill any tumor tissue which might remain.

**Course:** The patient made a good recovery and was discharged from the hospital September 13, 1928 (Fig. 5). A year later the patient was attending to her household duties and was in excellent condition. Her visual field on the left increased but the vision in the right eye remained unchanged. Microscopic examination proved the tumor to be a typical meningioma (Fig. 6).

**Comment:** This then was a patient of middle life who had developed a bilateral anosmia of which she was unaware; a complete blindness in the right eye with primary optic atrophy; mental symptoms

and involvement of one upper extremity because of an increase in intracranial tension. The latter had only recently



FIG. 6. Photomicrograph of meningioma removed. Van Gieson stain.

produced the first evidences of a beginning contralateral papilledema. Foster Kennedy<sup>10</sup> first called attention to this syndrome and recently Cushing<sup>11</sup> has considered these olfactory groove meningiomas in his Macewen lecture.

It has been the aim to remove meningiomas intact at one operation, but even when they are situated more favorably this may prove to be a difficult proceeding because of the extreme vascularity of the tumor, its attachments and the surrounding tissues. It may be imagined what trauma to the overlying frontal lobe might ensue and what uncontrollable hemorrhage might accompany an attempt to remove a tumor in such a location.

It is under such circumstances that the use of an electrosurgical unit has proved so valuable. It has resolved itself into the application of the well-known principle of an intracapsular enucleation such as has been used in the past for the removal of acoustic neurinomas. In other words we now have at our command a method by which a relatively inaccessible, highly avascular, tumor may be removed in its

entirety which previously would most certainly have proved inoperable. Though more accessible meningiomas have been removed in the past with success, nevertheless they are now approached with less fear of the necessity of multiple operations or of blood transfusions or refusions as life-saving measures.

#### GLIOMAS

The use of electrosurgery in the surgical treatment of the gliomas offers a more difficult problem than that presented by the meningiomas. It is however even of more importance when we realize that this group constitutes 42 per cent of all intracranial tumors. The problem of dehydrating, coagulating or cutting through gelatinous, soft, spongy, tumor tissues is so different that an attempt to loop out the tumor is in the majority of instances impossible.

The histological classification of the gliomas according to the predominance of glia cell types has been a tremendous step forward in our knowledge of the clinical course and surgical possibilities offered by these tumors. We have learned that the spongioblastoma multiforme is the most malignant of the gliomas and that a complete surgical removal is practically impossible. But we have also learned that the astrocytomas, the hemangioblastomas, and the slowly growing oligodendrogliomas offer encouraging and often brilliant results from surgical treatment. To this list through the work of Cushing with the aid of the electrosurgical unit, we may now add the medulloblastomas, a tumor most frequently found in children arising within the fourth ventricle. Many times it is necessary to split the vermis of the cerebellum to expose these tumors adequately. The technic of this procedure has been simplified immeasurably by the use of the combined cutting and coagulating current. While these tumors are soft they are nevertheless of firm enough structure to make their removal by the loop electrode possible. However, control of the vessels

entering these tumors laterally and below is the greatest problem to be met. Electrocoagulation is simpler and safer than the use of silver clips. When one realizes the size which these tumors attain and the physical condition in which we find these young patients after protracted vomiting bouts, any method which adds to the comfort of the surgeon is welcomed.

In our hands the electrosurgical unit has not added to our successful treatment of the large succulent, infiltrating spongioblastomas. These soft, gelatinous, cystic tumors do not lend themselves to piecemeal removal by electrosurgery. Yet even here the removal of a large block of cerebral tissue including the tumor is made less difficult by coagulation of the cortical and subcortical vessels. One may thus work in a comparatively avascular field. It is in such tumors that a partial or total lobectomy must be considered and while we are not in accord entirely with such radical procedures, nevertheless electrosurgery has made such a procedure less formidable.

However, as we stated, it is with the firmer and better defined gliomas that electrosurgery has proved of inestimable value. Our experiences with such situations may be illustrated by the following case.

*Headaches, bilateral papilledema, uncinat seizures without localizing symptoms. Right subtemporal decompression. Relief of headaches and subsidence of papilledema. Recovery and return to work—One year later return of uncinat attacks. Weakness of right arm and right side of face. Ventriculograms showed filling defect of left inferior horn. Left osteoplastic craniotomy. Removal of astrocytoma from left temporal lobe. Recovery.*

Mr. George W., aged thirty-six, was referred by Dr. T. A. Baumann of Rockford, Illinois, on January 1, 1928.

*History:* Since July of 1927 the patient has complained of severe headaches accompanied by vomiting. At that time he began to have attacks of loss of consciousness, lasting a short time and always preceded by a bad odor and taste. These attacks had occurred as often as three times daily. In November of that year he noted a marked diminution of vision.

*Examination:* The patient was in extreme

pain from his terrific headaches which could be relieved for short intervals by hypertonic glucose solution. There were no neurologic find-

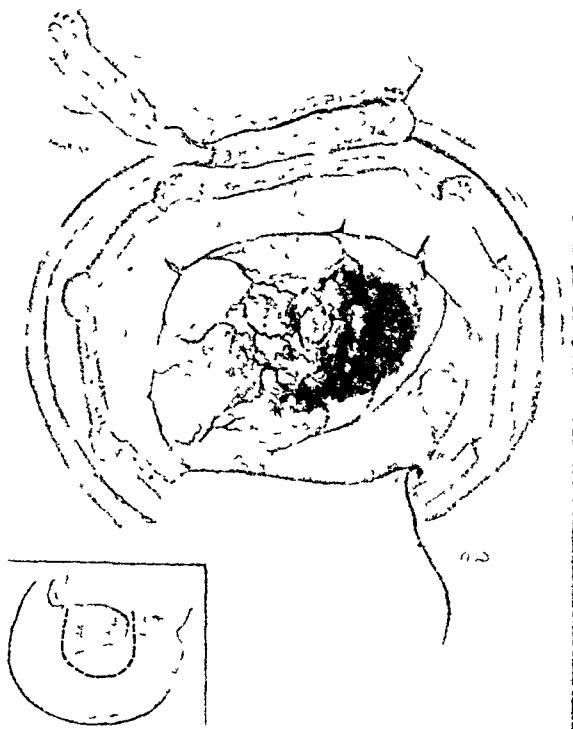


FIG. 7. Drawing elaborated from operative sketch which shows surface appearance of large glioma in temporal lobe.

ings which pointed to a lateralization of his intracranial lesion. There was a bilateral papilledema and a marked enlargement of his blind spots.

*Operation:* On January 6, 1928, a right subtemporal decompression was performed. The postoperative recovery was excellent. The headaches were relieved completely and there was a rapid subsidence of his papilledema. The patient returned to work but was examined monthly for evidence of localization.

*Re-entry:* On December 8, 1929, the patient was readmitted to the hospital. There had been a return of his uncinat attacks and he now presented a slight weakness of the right side of the face and of the right arm. He did not complain of headaches and his optic discs were flat.

*Ventriculography:* A ventricular study was done and air was injected. The ventriculograms showed a filling defect in the tip of the inferior horn of the left lateral ventricle.

*Operation:* On December 10, 1929, a left osteoplastic flap was made and the temporal lobe was exposed. The anterior portion of this



lobe was soft, yellow in appearance and relatively avascular (Fig. 7).

With the ball electrode of the electrosurgical

temperature reaction and no evidence of a late secondary hemorrhage. Microscopic examination proved the tumor to be an astrocytoma



FIG. 8. a, Coagulation of surface vessels with ball electrode; b, incision of cortex with flat blade electrode; c, removal of tumor with loop electrode.

unit the surface vessels were coagulated (Fig. 8a). The cortex was then incised longitudinally with the flat blade electrode (Fig. 8b). The brain tissue fell open in the characteristic manner and the tumor tissue was looped out with the electrode (Fig. 8c). As we got into the tumor we found that it was soft and gelatinous and the sucker was used to remove a great part of it. Soft tumor tissue could be seen extending medially and posteriorly and consequently remaining temporal lobe tissue was removed intact back to normal appearing cortex. That part of the tumor which remained on the floor of the middle fossa was removed with the loop electrode. The inferior horn of the ventricle was thus opened. At this stage a large subcortical vessel was ruptured. This was grasped with a tissue forceps and coagulated. A piece of muscle tissue from the patient's leg was placed over the opening in the lateral ventricle. After we had obtained a clean, dry wound the bone flap was replaced after the cavity was filled with saline solution.

*Course:* The patient's convalescence was quite remarkable and he left the hospital December 21, 1929 (Fig. 9). There was no

(Fig. 10). The patient has remained well and free from all symptoms and is now at work upon a farm.

*Comment:* In the past the technic of attacking such a tumor has been to ligate the superficial vessels with silver clips, to cut through the cortex and then by cotton pledget dissection to circumscribe the growth. After the tumor has been uncapped in such a fashion the softer gliomas have been handled quite advantageously by use of the sucker. One should not gain the impression that electrosurgery has superseded this technic completely. What has been added is the greater ease with which cortical or subcortical vessels are treated. It is far simpler to keep the field of operation free from blood, and in removing gliomatous tumor tissue it is extremely important to keep the plane of dissection dry. Moreover, it is of the greatest importance to uncapp the tumor widely, particularly if it lies subcortically before attempting its removal. To effect

this step the coagulating current is a great aid. Nothing is of a greater disadvantage than to have bleeding occur which spreads

There is no doubt that the use of the current produces some change in the adjacent brain tissue which remains be-



FIG. 9. Patient upon day of discharge from hospital. Note inconspicuous wound.

into normal cortical tissue. This only adds to the difficulty which already exists in determining the extent of a glioma into the surrounding normal brain tissue.

It must be emphasized that the electrode is of little use in soft, gelatinous tumor tissue and it is under such conditions that one must rely, as we have in the past, upon the suction apparatus. Further, larger subcortical vessels may be encountered which cannot be coagulated with safety, and consequently we cannot dispense with the use of silver clips. However, we feel that the addition of the electro-surgical unit has allowed us to be more radical in the removal of subcortical gliomas with greater safety to the patient and the experience cited here is an illustration.

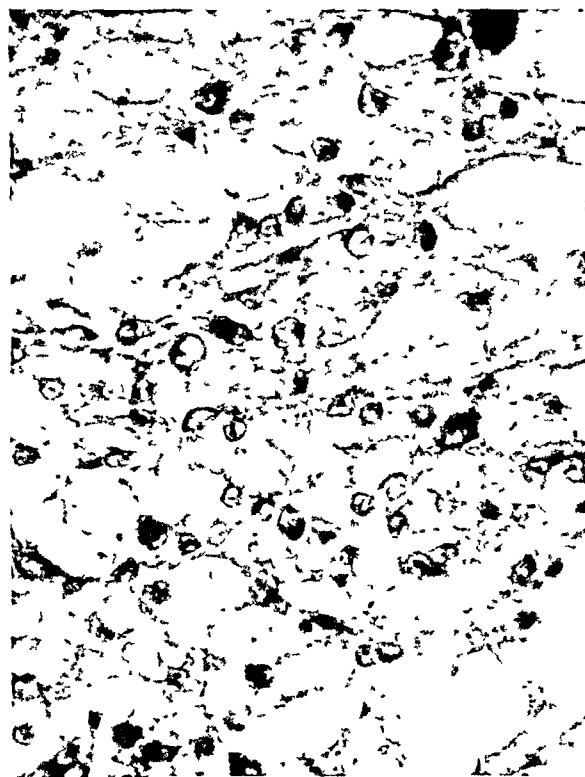


FIG. 10. Photomicrograph of tumor removed. H and E stain, Leitz objective 10 X, ocular 6 X.

hind. This is not represented by a charred, necrotic surface which may be expected to slough. In fact the change is not a macroscopic one. However, microscopic sections show a loss of the staining qualities which normal brain tissue possesses.

#### OTHER INTRACRANIAL TUMORS

**Angiomas:** While these tumors are comparatively speaking of infrequent occurrence within the brain, one needs only to meet with one at operation to be impressed with the difficulties surrounding their surgical treatment. To expose a mass of vessels which resemble more than anything a tangled mass of angleworms and to judge the wisest procedure to employ is a situation which taxes one's surgical judgment. Even the help of the coagulating electrode is not the all-encompassing comfort that it might seem to be.

However, by beginning with vessels

at the periphery of the lesion and by the use of a slow coagulating current, in many instances we may reduce these tumors to a shrunken charred mass. The greater danger lies in attempting to coagulate the vessels too rapidly. The wall of one of these aneurysmal vessels may be sparked through and troublesome, if not uncontrollable, bleeding occurs. Certainly, before the use of electrosurgical methods the treatment of these lesions consisted entirely of a decompression operation and the use of x-ray therapy.

*Acoustic Neurinomas:* These encapsulated tumors arise from the eighth cranial nerve in its short intracranial course. They occupy the space known as the cerebellopontile angle, and therefore by pressure involve the cerebellum, pons and other cranial nerves which arise from the lateral aspect of the pons and medulla. While they are quite benign in themselves, their increase in size gives rise to a clinical syndrome of disabling symptoms which are characterized by the chronology of their development. They are rather easily recognized but their surgical exposure offers a serious problem.

The surgical removal of these tumors must be governed in part, at least, by the fact that in one's desire to remove the entire growth irreparable damage may be done to the adjacent nerve structures. In the past we have been content to remove the tumor tissue by incising the capsule, and to leave the latter structure in place. When one visualizes the vessels which supply the tumor and which come from the pons, the uncontrollable hemorrhage which may be encountered is easily understood. A further difficulty is offered by the fact that these medial vascular attachments of the tumor to the pons cannot be visualized clearly.

Electrosurgery has afforded several distinct advantages. First, intracapsular removal by looping out the tumor tissue may be done more quickly and quite bloodlessly. The loose capsule may then be removed by carefully coagulating each

of the vessels leading into the tumor. This is easier to do than to place silver clips on these vessels in a necessarily deep wound. Moreover, many of these tumors are situated rather high in the angle and the overlying cerebellar cortex makes it difficult to obtain a satisfactory view of the mass. Under such conditions removal of the lateral portion of the cerebellar hemisphere would be of considerable help. In the past such a procedure was tedious, slow, and likely to be accompanied by more damage than was desirable. It has been shown that such a removal of a portion of the cerebellar hemisphere may be compensated for by the patient. The use of the electrode makes it possible to remove this part of the cerebellar lobe rapidly and without loss of blood. The resulting symptoms may prove to be less formidable than those produced by the necessary retraction of a cerebellar hemisphere which is left in place.

#### SUMMARY

There can be no doubt that the use of electrosurgery adds a complex piece of surgical equipment to a technic already dependent upon meticulous attention to detail for its success. The surgeon, of course, does not have to be acquainted with all of the laws of electrical physics to employ such an apparatus successfully. However, a thorough acquaintance with its performance obtained upon experimental living structures is necessary before one should attempt its use during a complicated surgical procedure. Even with such a preparation, the advantages and limitations of its use are indicated more clearly by practice. That some surgeons may find it of more value than others to gain the same result is a fact which depends entirely upon the individual's surgical technic. It should be emphasized again, therefore, that electrosurgery cannot be said to have superseded the basic principles of osteoplastic cranial operations and tumor removal.

It has been our experience that one is likely to hurry the procedures of coagulat-

ing vessels or incising brain tissue. As has been pointed out, the use of a strong current to coagulate a vessel may cause it to explode and to defeat the object for which it is intended. It is certain that the electrodes are of no service whatever in a bloody field which does not allow one to see the bleeding or oozing point.

It is of course understood that an electrosurgical apparatus should not be used during the administration of a general anesthetic. The possibility of an explosion is too factual to be dismissed. Consequently the operations in which the electrodes are used are performed under local anesthesia. The disadvantages of a general anesthetic such as ether in intracranial operations are well known, so that the necessity of a local anesthetic in itself is of value. However, it must be recognized that many individuals are not suitable patients for the use of local anesthesia. In such circumstances we have taken the precaution to remove the ether bottle from the room, and have placed a wet cloth between the patient's face and the operative field while the unit is in use.

We have satisfied ourselves that there are not untoward or disturbing complications due to the use of this apparatus in intracranial surgery. As a matter of fact the immediate postoperative convalescence in all the cases in which it has been used has been smooth and uneventful. We have never had to re-elevate a flap in this group of cases because of secondary hemorrhage. Neither do we believe that any greater amount of postoperative edema follows its use.

In conclusion, we believe that:

1. Electrosurgery is a distinct addition to the neurological surgeon's armamentarium. It does not however completely supercede the well established principles of osteoplastic craniocerebral surgery.

2. At present, it may be employed to its greatest extent in the removal of meningiomas; in particular, to the relatively inaccessible meningiomas.

3. The improvement of the use of electrosurgery in the surgical treatment of gliomas offers the possibility for its greatest contribution to the surgery of the nervous system.

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# NEPHROPTOSIS

## ITS RELATION TO THE LIVER, SPLEEN, STOMACH AND ITS CORRECTION BY MEANS OF A NEW OPERATION

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FOR several years, the author has been confronted with a number of cases which have presented a complex train of symptoms referable to urinary, gastrointestinal, biliary and nervous systems. Many of these patients have passed from one branch of medicine to another without obtaining relief of symptoms after much internal medication and in some instances even after surgical procedures had been tried. The symptom complex has led the physician to the ptosed kidney condition as representing the paramount pathological lesion, but its relation to hepatoptosis, cholecystitis, general visceroptosis, kinks and strictures of the ureter, infections of the kidney, rotations of the kidney, pelvic capacity and kidney functions has not been clearly defined. It is the twofold purpose of this paper first to present the data obtained from a study of a series of such nephroptotic cases and secondly to submit a new operation for nephroptosis.

While the nephroptotic kidney case is a frequent visitor to the urological clinic it is difficult to find a large series of these cases which have been so thoroughly studied that one may extract the details relative to size, shape, position, function and mobility of all the viscera.

In all 55 cases were available for study. These were all cystoscoped routinely. The phenolsulphonphthalein functional tests were done intravenously, the urines were examined immediately and cultured, the capacity of the kidney pelvis measured, the x-rays were taken with the patients in the supine and erect positions. Where the stomach was not outlined by gas, a bismuth series was done. Those cases which had

symptoms referable to the gall bladder or biliary ducts, were given the Graham test. The excursions of the kidneys were measured on the films. There was a very slight error in the result of measuring the movement on the film but all x-rays were taken under the same conditions.

The excursion of the kidneys varied from 4 cm. to 12 cm., the average being 5.5 cm. Fifty-one per cent of the ptosed kidneys occurred on the right side, 11 per cent on the left side and 19 per cent were bilateral; 7 per cent of the cases showed general visceroptosis. These latter cases with general visceroptosis gave a history of ten years or more of pain; while the others gave a history of pain less than three years' duration. Hepatoptosis only occurred in those cases with general visceroptosis. In 40 per cent of the cases there was a long right lobe of the liver. The lobe moved in and out with respiration but not up and down with the kidney. In none of the cases was there an actual enlargement of the liver, 8 of the 55 patients have been proved to have gall bladder disturbance, 5 of these 8 had a history of jaundice, 4 of them had had the gall bladder removed in which were found gallstones, 3 of the remaining 4 had positive Graham tests before nephropexy. One who had a positive Graham test before the nephropexy had a negative Graham test afterward. Dr. Scholl of Los Angeles has called attention to the coexisting gall bladder disturbance in nephroptotic cases. MacLagan and Treves of London report 3 cases in which a diagnosis of gallstones was made but at operation found a ptosed right kidney causing a cystic duct kink.

The spleen was found ptosed only in

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the general visceroptotic individuals. Even in the bilateral renal ptosis cases the spleen did not move abnormally but was sympathetic with the liver.

The rotation of the ptotic kidney has rarely been observed or if so not given enough discussion, 20 per cent of the kidneys were rotated through one or more planes up to 180°. This observation is important in correcting the position of the kidney at operation.

The function of the ptotic kidney is rarely modified, for only 2 of the 55 cases showed any diminution. These 2 cases had a history of long-standing bilateral kidney infection with *Bacillus coli*. Thirty-three per cent of the kidneys were infected, all with *B. coli*; most of the pelves which were infected had a slight increase in capacity although only 7 per cent had more than 20 c.c.; 66 per cent had a normal pelvic capacity. All the cases had either a kink, stricture or a tortuosity of the ureter; 80 per cent showed kinks; 50 per cent a tortuosity and 13 per cent stricture. The ureter in all these cases is redundant and must therefore have an abnormal course when the kidney drops. The strictured ureter elongates; hence, in this condition we also find an angulated or a curved course for the ureter. The ureteral strictures occurred in the upper third so that bladder symptoms were only present in those patients who had a urinary infection.

The symptoms of the ptotic kidney are mainly pain, acute and chronic, due mostly to obstruction of the ureter. The emptying time of the kidney pelves has been determined in a few cases only. It is an important observation and should be noted in all cases. In cases so far observed it varied from fifteen to ninety minutes and some longer as they were not followed after this length of time.

In the treatment of renal ptosis the emptying time must be made to fall within a normal period. The ureter is at fault but only secondarily so. Burford and Reilly are performing nephropexies for ureteral kinks. Crabtree suggests nephropexy for ureteral kinks with infections.

Not all cases need kidney elevation to obtain drainage. Some respond to passage of a bougie or catheter. Some nephroptotic cases have become free from infection by a few of the usual dilatation and irrigation treatments; others require treatments every six or twelve months. These cases which respond to the conservative treatment have an emptying time of less than twelve minutes. Other cases have such tortuous, kinked and strictured ureters that it is impossible to pass a catheter or bougie up to the kidney pelvis; some have extraureteral adhesions which make kinks with the ptosis and they too do not allow ureteral instruments to pass. Such patients as are incapacitated for work or locomotion are advised to have operative treatment. Since only one-third of the instances here given have been operated upon, the author feels that if there is error in surgical treatment it has been in the favor of conservatism.

The operator should aim to give free drainage to the kidney and ureter by restoring the kidney to its normal position and freeing the ureter of its kinks and strictures. All the operations thus far recommended in the literature either subject the kidney to serious infections, mutilate its capsule or destroy a portion of the parenchyma by puncturing sutures. With the idea of conservation of the functioning portion of the kidney as well as its capsule the author submits the following operative procedure:

*Author's Operation:* The incision is begun high in the costovertebral angle, continued downward and transversally across half-way between the lower rib and crest of the ilium incising in most cases portions of the external and internal oblique muscles. Approach to the kidney is made through the triangle of Petit. Care is taken to push the twelfth thoracic nerve downward in dividing the transversalis muscle and to leave enough fascia margin, so that when the wound is closed, the nerve will not be caught in the suture. The fatty capsule is opened and the kidney which is usually low in position is easily recognized.

The perirenal fat is all stripped off the kidney which, with its vessels and ureter, is then delivered into the wound. It is important that all adhesions be removed from the upper as well as the lower pole. The ureter which is either tortuous or badly kinked should be made free. The pedicle in all cases is long so that the surgeon should not encounter any difficulty in delivery of the kidney. Special attention should be made concerning the kidney fossa, whether shallow, absent or deep. The liver sometimes is adherent to the posterior abdominal wall so that it is impossible to place the kidney in its bed without freeing up the right lobe. The hand should be inserted under the right lobe of the liver to the diaphragm. When this is done the kidney can be replaced sufficiently high to remove all kinks and most of the tortuosities of the ureter. Lowsley and Kirwin state that the kidney cannot in all cases be placed sufficiently high to obviate the kinks. The reason for this is the elongation of the ureter. The kidney can be made to occupy practically an intrathoracic position with the lower pole lying opposite the last rib. The upper pole should be carried medially and the lower pole outward to give dependent drainage to the lower calyx.

With the kidney held in this position a series of interrupted mattress chromic No. 0 sutures are placed through the perirenal fascia and peritoneum to the quadratus muscle. Perirenal fascia is always excessive so that it can be easily approximated. Precautions must be taken not to include the bowel medially. The first stitch should be placed about 1 cm. from the ureter and as high up as possible on the quadratus muscle posteriorly. Care should always be taken not to include any of the nerves in these sutures of chromic gut. A series of five to eight sutures are necessary to close this aperture. This forms a basket-sling for the kidney so that it is impossible for the organ to descend. This row of sutures is now enforced by bringing up all the extraperitoneal fat and suturing it with two or

three mattress sutures to the quadratus muscle below the other line of sutures. This acts as a support and fills the space previously occupied by the kidney. The wound is then closed in layers with No. 2 plain catgut and the skin with interrupted silk without drainage.

The patient is kept flat in bed for sixteen days, allowed out of bed on the eighteenth day and home on the twenty-first or twenty-second day. None of the cases developed complications and all but one were completely relieved of the symptoms. The one failure was not the fault of the operation but an error in application as the kidney pelvis had a capacity of 40 c.c., was infected and the ureter badly strictured.

All the cases have had follow-up cystoscopies either at the time of discharge, at one year or later. One has had a cystoscopy with urograms after a pregnancy and the kidney found to be in the same position as it was placed at operation. Six of the 7 cases that had kidney infection previous to operation cleared afterward. Several of the cases with strictured ureter had dilatations following the nephropexy and remain perfectly well.

#### CONCLUSIONS

1. Visceroptosis is rare with nephroptosis.
2. Gall bladder disease is not an uncommon complication of nephroptosis.
3. Hepatoptosis is apparent and not real, due to a long Riedel's lobe.
4. Ureteral lesions occur in the upper third.
5. Kinks are secondary to ptosis.
6. Rotation of the kidney is common.
7. Renal infections occur in 33 per cent.
8. Some nephroptotic cases respond to conservative treatment.
9. A new and successful operation has been devised which does not in any way injure the kidney or its capsule and which utilizes all the natural supporting structures and places the kidney in an anatomically correct position.

[For discussion of this paper see p. 229 and for bibliography see author's reprints.]

# TUBERCULOSIS OF THE KIDNEY

A CRITICAL REVIEW BASED ON A SERIES OF TWO-HUNDRED TWENTY-ONE CASES\*

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THIS paper is based upon a series of 221 cases that have been under my personal observation. It does not represent all the cases of renal tuberculosis that have been seen, but only those with records of sufficient data which made it worth while to study them and to include them in a presentation of this kind.

In some of the early cases certain data are completely absent. This is due to the fact that the present-day methods of examination were not in use at the time these early cases were seen; for example, in the early cases pyelograms were not made and later on they were made at only very rare intervals. Likewise routine roentgen-ray examinations of the urinary tract as well as of the chest were not carried out, whereas today this is done as a routine procedure in all cases of tuberculosis of the kidney. Other data, however, were present in sufficient amount to make the cases available for study.

## FREQUENCY

Because there is a gradual and progressive reduction in the incidence of pulmonary and glandular tuberculosis, it is but natural to expect that there should be a corresponding diminution in the incidence of renal tuberculosis; no doubt in the future this will come to pass. However, present-day statistics, according to Wildbolz, showed that in a series of 2345 autopsies performed in six years in the Pathological Institute in Berne, Switzerland, tuberculous foci in the kidney were found present in 5.3 per cent. The lungs in this same group of cases showed tuberculosis in 20.7 per cent. A somewhat different aspect of the frequency of renal tuberculosis is obtained from the statistics of Braasch who reported

a series of 532 persons operated upon for renal tuberculosis; during this period 85,000 patients were operated upon and he stated that the incidence of surgical renal tuberculosis may be estimated as 0.6 per cent. The variation in these statistics, no doubt, is due to the fact that in one group of cases the disease process was far advanced and probably resulted in the death of the patient, whereas in the other, a clinical group, the diagnosis was made early.

## HISTORY

One cannot too often stress the importance of a carefully obtained history in any surgical condition. This applies particularly to cases of renal tuberculosis since many times one is amply rewarded for his trouble. In taking a history one may receive his reward from statements that immediately focus one's attention on the possibility that the patient's present complaint may be tuberculous in origin and may be the sequence, directly or indirectly, of a previous operation for some tuberculous disease elsewhere in the body. One of the amazing things brought out in this study is the fact that in this series of 221 cases there were 43.5 per cent in which the patients gave a history of having had some sort of a previous operation. Forty-two of these cases, or 47.7 per cent, had had an operation for a tuberculous disease.

For the purposes of discussion these previous operations may be considered under the following headings: (1) operations for tuberculous lesions of the genito-urinary tract; (2) operations for tuberculous lesions outside the genito-urinary tract; (3) operations for the relief of symptoms complained of and for which no

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relief was obtained from said operations; (4) operations without relation to the present trouble.

*Group I.* In this group of 28 cases the largest number had been operated on for genital tuberculosis. One half of this total, or 14 cases, had had a previous castration and one had a double castration. The fallacy of performing a castration in tuberculosis of the genital tract needs no discussion at this time. I think we are all in accord with the fundamental principle that tuberculosis of the epididymis is best treated by epididymectomy and not by castration.

TABLE I  
OPERATIONS FOR TUBERCULOUS LESIONS OF GENITO-  
URINARY TRACT

	No. Cases
Castration	14
Epididymectomy	6
Epididymectomy and appendectomy	1
Double castration	1
Previous nephrectomy	2
Previous kidney drainage	2
Decapsulation of the kidney	1
Kidney drained and psoas abscess drained	1
	<u>28</u>

*Group II.* In this group there are 14 cases. Thirteen cases gave a history of a previous operation for a very obvious tuberculous lesion outside the genitourinary tract. In one case the nature of the operation could not be definitely determined. It is

TABLE II  
OPERATIONS FOR TUBERCULOUS LESIONS OUTSIDE THE  
GENITOURINARY TRACT

	No. Cases
Tuberculous glands of the neck	2
Tuberculous glands of the groin	2
Fistula in ano	1
Fistula in ano and osteomyelitis of hip	1
Psoas abscess	1
Perirectal abscess	1
Osteomyelitis of the elbow	2
Tuberculosis of the knee	1
Tuberculosis of the shoulder	1
Tuberculosis of the ulna	1
Operation on hip (T. B.?)	1
	<u>14</u>

undoubtedly of value to elicit, if possible, from the patient's physician or from the

hospital at which the patient was operated upon, information regarding previous operations, unless, of course, one feels sure from the patient's statements and the results obtained at the physical examination, that the evidence is convincing enough without further investigation. Lesions of the bones and joints predominate in this group.

*Group III.* In this group there were 26 patients who consulted their physicians because of various urinary symptoms. Their urinary symptoms, their cause and significance, were not appreciated and the patients were subjected to a surgical procedure without obtaining the desired relief. As one might expect, appendectomy heads the list and in this group there were 10 patients who had had their appendices removed. There were more appendices removed than have been listed in this series, as the cases of perineal repair also had had an appendectomy. There were 4 genitourinary operations performed in this group, 2 suprapubic cystotomies and these were done for the specific purpose of bladder drainage, 1 external urethrotomy, and 1 case was allegedly operated upon for a stone in the bladder but the patient never saw the stone. These patients obtained no relief from these operations.

TABLE III  
OPERATIONS FOR RELIEF OF SYMPTOMS WITHOUT  
OBTAINING RELIEF

	No. Cases
Appendectomy	10
Suprapubic cystotomy	2
External urethrotomy	1
Stone in bladder?	1
Perineal repair	4
Exploratory laparotomy	3
Fibroids	1
Hemorrhoids	1
Curettement	1
Salpingectomy and oophorectomy	2
	<u>26</u>

*Group IV.* In this group the subject of a previous operation is one of incident only, since the operations, as far as it was possible to say, had no relation to the patient's present trouble. Tonsillectomy heads this group.

TABLE IV  
OPERATIONS WITHOUT RELATION TO THE PRESENT TROUBLE

	No. Cases
Tonsillectomy.....	17
Gallstones.....	2
Hemorrhoids.....	2
Hyperthyroidism.....	1
Mastoid.....	1
Nasal.....	1
Carcinoma of breast and (pelvic lavage?).....	1
Hernia.....	2
Abscess (nature?).....	1
	<u>28</u>

THE INCIDENCE OF AGE

It is generally believed that renal tuberculosis is primarily a disease of adult life and a review of the age incidence in this series bears out this general view. The largest number of cases occurring in any one decade was 73, the ages ranging between twenty and twenty-nine. More than one-half of the cases, or 56 per cent, occurred between twenty and thirty-nine years. The youngest patient was a female, seven years of age, and the oldest was a female, sixty-nine years old, and between these two limits the following distribution of ages is to be noted.

TABLE V  
AGES

Years	No. Cases
7.....	1
10 to 19.....	23
20 to 29.....	73
30 to 39.....	51
40 to 49.....	40
50 to 59.....	21
60 to 69.....	5
Not stated.....	7
	<u>221</u>
Youngest, female.....	7 years
Oldest, female.....	69 years

It would appear that renal tuberculosis in infancy and childhood is uncommon. In this series only 1 case occurred before ten years of age. No doubt, with the widespread interest in urology in children, some of the cases of so-called chronic pyuria and perhaps some of the cases of so-called chronic pyelitis may ultimately prove to be due to renal tuberculosis. Recent autopsy statistics have given us a somewhat different viewpoint; thus,

Rilliet and Barthez demonstrated renal tuberculosis in 15.7 per cent of 312 autopsies done on tuberculous children, and in the Pathological Institute in Berne, in a series of 126 autopsies on tuberculous children, 13 cases, or 10 per cent, of renal tuberculosis were found.

SEX

The question as to which of the two sexes is the more frequently afflicted with this disease seems at this time to be in a state of uncertainty. The figures on this subject will depend in part upon the type of practice carried out by the individual who reports the cases; some urologists operate upon and see a preponderance of males, hence, they naturally would report a series in which males predominate. On the other hand, a gynecologist, reporting a series of cases, would naturally report more women.

In this series there were:

	No. Cases	Per Cent
Males.....	123	55.6
Females.....	98	44.3

Wildbolz, in his series of 245 cases which included both operated and non-operative cases, found practically no difference in the sexes. The statistics of Braasch, on the other hand, showed approximately twice as many males as females, the males being 63.5 per cent and the females, 36.5 per cent.

SIDES INVOLVED

Much more important than the question of age and sex incidence is the question of whether or not in a given case one is dealing with a unilateral or a bilateral disease process. After all, it makes very little difference whether the patient has the tuberculosis on his right or left side, other than for statistical or academic proof or reasons. Much more important, of course, is the question of whether the lesion is unilateral or bilateral. This assumes great importance from the stand-

point of treatment and raises the question of the surgical removal of one of the two diseased kidneys in cases in which the disease process is bilateral.

Even after a very careful, painstaking examination that shows one kidney to be normal, because of a clear urine that is free of pus and negative for tubercle bacilli, there always exists the possibility that one has failed to find tubercle bacilli, or again, the possibility that in the particular kidney a focus of tuberculosis exists that has not or does not communicate with the pelvis, hence, cannot be detected. In one of our cases this point was taken up in great detail and a most careful, painstaking search for tubercle bacilli was made in the urine from the opposite or healthy kidney. Repeated guinea pig tests were made but they were all negative. The patient, a boy of eighteen, died three months after the operation of tuberculous meningitis and at autopsy a very small tuberculous lesion was found in the remaining kidney.

The importance of this point is apparent both from the standpoint of prognosis and postoperative duration of life and also has a bearing on the value and the results of surgical treatment.

The seriousness of the responsibility of determining whether or not the opposite kidney is free of tuberculosis is a question that I always enter into with a feeling of grave responsibility, particularly since my experience in the case just mentioned. I always make it a rule to regard the opposite kidney with suspicion until the presence in it of a tuberculous focus can be positively excluded.

When the laboratory report shows one or two tubercle bacilli, in the urine from the supposedly normal side, and the urine contains only a few leucocytes, the problem of evaluating these findings is exceedingly serious. The question of regurgitation of infected bladder urine alongside the catheter has been discussed by Dr. Beer and the question of dragging infected urine up from the bladder by means of

the catheter has been emphasized. The possibility of dragging up organisms by the catheter can be negated by plugging the ends of the ureteral catheters with large bank pins, a procedure carried out in many clinics.

Formerly, in order to determine this point, a very careful study of renal function was advised and carried out. Unfortunately, just in this group of cases the lesion is small and the destruction of kidney tissue minimal, so that there is not much renal impairment, therefore not much difference in function.

It is just in this group of cases that I have felt justified in making a pyelogram to determine whether or not an early lesion is present. With this sort of problem before us I think an unusually careful reading of a pyelogram will clear up this point, and I believe pyelography in this group of cases is of much more value than is a study of renal function. It is my impression that one of the very important problems in renal tuberculosis is the determination of this point, and it is my personal conviction that, with more time and study devoted to this particular problem, the number of bilateral cases will increase in number in any given series.

The same problem confronts one in suspected cases of unilateral renal tuberculosis in which one or two tubercle bacilli are found in a clear urine or in urine that contains only a few leucocytes.

Of one thing we can be certain and that is that in this group of cases there is never any hurry to operate; hence, ample time is at hand for careful and, if necessary, repeated clinical investigation. The course of the disease is slow and should any doubt exist in my own mind, I wait for the results of the first guinea pig inoculation, made at the time of the first cystoscopy. If the first examination is negative and if one has reason to question the condition of the kidney to remain, I never hesitate to subject the patient again to a second complete urological study; that is, another cystoscopic examination is done, the catheter-

ized kidney specimens are again most carefully examined for tubercle bacilli, another set of guinea pigs are inoculated and perhaps another set of pyelograms made. I await the result of the second set of guinea pig inoculations. There have been instances in which even a third complete urological survey was done, but instances are very rare.

This, of course, does not apply to the cases in which one is dealing with a frank unilateral renal tuberculosis and cases in which there is no question about the opposite side.

Much has been said and written about the early recognition of renal tuberculosis and the institution of early surgical treatment. With this view I am wholly in accord. Nevertheless, in spite of this dictum, I would rather wait several months so as to check up and be sure, where doubt may exist, rather than remove a normal kidney. Much evidence can be advanced for and against this delay, but I do not know of a single instance in my own experience in which delay led to a bad result or caused regret.

In this series of cases there were 41 bilateral cases of renal tuberculosis, or, in other words, a percentage of 19.3. Even these figures may be in error in that they are too low, because, as already mentioned, it is relatively easy to miss a small focus that may be present at the time the patient is under examination. These figures, therefore, represent a minimum incidence and not a maximum one.

With the importance of accurate diagnosis before us, associated with the development of new culture methods for growing tubercle bacilli, as well as a renewed interest in developing better technic for showing the organism in smears, coupled with the refinements in roentgen-ray diagnosis of the various types of calcification seen in the renal area and supplemented with the additional help of pyelography and, finally, with a keen appreciation of the seriousness of the subject at hand in each given case, the result, I believe, will

be an increasing number of cases of bilateral renal tuberculosis.

Wildbolz in his series of 245 cases found bilateral renal tuberculosis in 12 per cent of the cases. Brongersma reported a series in which the lesion was bilateral in 14 per cent and Braasch found 16 bilateral cases in his series of 532 cases, or 3 per cent.

In this series there were 14 cases in which the side of involvement was not determined. By way of explanation may I state that this occurred in cases in which there was extensive tuberculosis of the bladder so that cystoscopic examination was exceedingly difficult; there were cases in which the ureters were not seen, cases in which only one side was catheterized and cases in which patients refused a complete urological survey and left before the examination was finished and cases that were proved elsewhere. This point will be considered in detail further on in this paper.

The difference between the frequency on the one side or the other is so slight as to make no practical difference. It is generally assumed that the right side, because of its greater mobility, is more frequently involved than is the left side, but the difference is so slight as to be of no great importance in the diagnosis or differential diagnosis.

Not only is it important not to overlook a bilateral case and, perhaps, perform an unnecessary surgical operation, but the opposite condition may exist in which the patient has been erroneously diagnosed as a case of bilateral renal tuberculosis. By this diagnosis he or she may be deprived of surgical treatment. As a matter of fact nephrectomy is the only therapeutic agent at hand for the patient.

#### THE PRESENCE OF PULMONARY TUBERCULOSIS

At the present time each case of renal tuberculosis is subjected to a complete physical examination and this includes, of course, a roentgen-ray examination not

only of the genitourinary tract but of the chest as well. This procedure is now being carried out as a routine, whereas, formerly, the physical examination only was done and was not checked up by means of the roentgen ray. These two methods of examination should be supplemental.

The roentgen-ray examination may often show the presence of an old healed lesion, or, may perhaps demonstrate a very small lesion, both of which may be missed following a physical examination. As a routine procedure I carry out both roentgen-ray and physical examinations, using one as a check against the other.

The records of 180 cases are available and they showed that there was evidence of involvement of the lungs in 35.5 per cent of the cases.

The old or healed cases had no effect upon the operative mortality. The cases in which active tuberculosis was found were carefully considered from the standpoint of the choice of an anesthetic.

#### THE PRESENCE OF TUBERCULOSIS IN OTHER ORGANS

The next largest group that showed the presence of coexisting tuberculous disease in organs other than the kidneys and lungs were the cases in which the genital tract in the male was affected by tuberculosis. As is well known, tuberculosis in the genital tract of the female is uncommon. In this series there were 123 males. The records show that 39 of them had involvement of the genital tract, that is, prostate and vesicles, and in 26 of these cases there was an additional involvement of the epididymis.

#### DURATION OF SYMPTOMS

Tuberculosis of the kidney is, of course, no exception to the rule that the best ultimate results are obtained in early cases. I think one is justified in stating that the largest number of cases are unilateral *early* in the course of the disease. Both autopsy and clinical statistics show that late in the course of the disease the

percentage of bilateral cases is very high. Furthermore, it is almost universally admitted that the best functional results, as far as the bladder is concerned, are obtained in cases in which there is a very slight or no involvement of the bladder. Nothing is quite so discouraging to both the patient and the physician as failure of an operation to relieve the symptoms that make life almost unbearable. It is just this type of case with its persistent great suffering that makes one feel justified in making a strong plea for the early recognition of renal tuberculosis and for instituting surgical treatment before there is much if any involvement of the bladder.

In 121 cases the symptoms had been present for one year or in 54.7 per cent. The next largest number had symptoms for two years and there were 33 in this group. Therefore, in 154 cases, or in 69.6 per cent of these cases symptoms had been present for two years before they came under observation and were subjected to correct diagnosis and treatment. The longest duration of symptoms was in the case of a female, aged fifty-eight, and they had been present for twenty-six years.

The amount of impairment of bladder function is of course in direct ratio to the duration of the disease and the persistence of the bladder symptoms after the operation is likewise due to the length of time that it has existed. Therefore, in order to

TABLE VI  
DURATION OF SYMPTOMS

Years	Cases
1	121
2	33
3	11
4	7
5	12
6	7
7	2
8	2
9	1
10	2
11	1
12	2
15	4
19	1
26	1
Not stated	14
	221

have a good functional result, treatment must be carried out before there is much destruction of bladder function.

### SYMPTOMS

Frequency of urination is one of the most constantly present symptoms that, as a rule, manifests itself early in the course of the disease and often persists long after the patient has been operated upon and the kidney removed and the bladder infection has cleared up. In this series frequency of urination was present in 184 cases or 83.2 per cent. Nocturia was present in 166 cases. The following table gives the symptoms in their order of frequency.

TABLE VII

	Cases
Frequency..	184
Nocturia..	166
Hematuria .	107
Pain on urination...	98
Pain in back..	88
Loss of weight.	65
Fever..	41
Chills..	27
Nausea..	22
Vomiting .	22
Renal colic...	15
Incontinence..	12

### URINALYSIS

It is generally believed that in cases of renal tuberculosis abnormal elements are present in the urine and of these elements pus in the urine heads the list. In this series pus was present in 201 cases, or 90.9 per cent. Following is the table of urinalysis:

TABLE VIII  
URINALYSIS

	Cases
Leucocytes.	201
Albumin..	171
Red blood cells	112
Casts.....	24
Not stated..	15

One must not lose sight of the fact, however, that the patient may present himself with a clear urine and that because of this fact the possibility of urinary tuberculosis may be overlooked.

### THE PRESENCE OF TUBERCLE BACILLI IN THE URINE

In this series the usual ordinary routine examinations for tubercle bacilli were carried out. In 194 cases, or 87.7 per cent, the presence of tubercle bacilli was demonstrated either upon smear or by guinea pig inoculation, or both. Of these 194 cases, smears made from bladder urine were negative in 13 cases in which the guinea pigs inoculated with the bladder urine were positive; smears made from the right kidney were negative and guinea pigs inoculated with urine from the right side were positive in 15 cases; smears of urine from the left side were negative, while guinea pigs inoculated from the left side were positive in 10 cases; hence, in those cases with negative smears, the positive guinea pig inoculations were of great additional aids in helping to make the diagnosis.

	Cases	Per Cent
Diagnosis made by demonstrating tubercle bacilli in the urine either upon smear or by guinea-pig inoculation . . .	194	87.7
Diagnosis made without demonstrating tubercle bacilli in the urine...	27	12.3

### DIAGNOSIS MADE WITHOUT DEMONSTRATING TUBERCLE BACILLI IN THE URINE

In 27 cases in this series the diagnosis of renal tuberculosis was made without demonstrating tubercle bacilli either in the urine or in the guinea pigs, that is, the diagnosis was made without bacteriological proof. These cases for study may be divided into two groups: the group in which the diagnosis was made by means of the x-ray findings in the flat plate and the group in which the diagnosis was made by the cystoscopic examination either with or without ureteral catheterization.

*Group 1:* In this group the diagnosis was made from the flat plate in 7 cases. These cases were further divided into two groups, those in which the x-ray picture was that of a so-called healed tuberculosis, this x-ray being typical and hardly to be

confused with any other roentgen-ray finding. In the second group the findings of the x-ray were in the form of small irregular areas of calcification, so frequently found in routine x-ray examinations that doubtless they are familiar to you. In a few of these cases, not only were these areas of calcification found in the renal areas but occasionally the areas of calcification were found outlining the course of the ureter. While the latter finding is rare, it is none the less a striking one that can hardly be confused in differential diagnosis.

*Group II:* In the remaining 20 cases the diagnosis was a clinical one and was based upon the following data: the history of a long-standing bladder disturbance, often aggravated by local treatment and the presence of a persisting pyuria that failed to respond to the usual internal treatment, led us to regard the patient as suspicious. A cystoscopic examination revealed the well-known findings of bladder tuberculosis such as the presence of a limited bladder capacity, the exceedingly painful cystoscopic examination, the presence of areas of ulceration and tubercle formation, changes about one ureteral orifice whereas the opposite was normal, the ureteral catheter often meeting an obstruction on the suspected side, and the presence of clear urine on one side and pus on the other. In other words, in this group the diagnosis was purely clinical *but was verified by operation or autopsy.*

In several instances the bladder tuberculosis was so extensive and so far advanced that cystoscopic examination and ureteral catheterization were decidedly unsatisfactory; hence, outside the fact that the diagnosis of tuberculosis of the bladder was made, no study of the kidneys was possible.

In several cases we resorted to the use of cystography as an aid: this showed the presence of reflux up the ureter with a resulting set of pyelograms that demonstrated bilateral tuberculosis. Reflux or regurgitation, as is well known, is not an

uncommon occurrence. Cystography is of great value in just this type of case.

In 2 cases of this series an exploratory operation was done. The exploratory operation was made in each case only after repeated attempts to obtain the necessary information in some other way which, because of the condition, rendered the examination nil. In one case the diseased side was catheterized and the exploratory operation was performed to demonstrate the presence of a normal kidney. I know that this method is rarely, if ever, justified. Furthermore, I also know that small tuberculous lesions may be readily overlooked in this way. That they were not overlooked in this case, however, is proved by the fact that this patient is alive and well fourteen years after her nephrectomy.

The other case of exploratory operation revealed the presence of bilateral disease far advanced.

It should be borne in mind that both these patients had had symptoms for many years and were the victims of the seat of advanced bladder tuberculosis. Furthermore, these cases were among the early ones and occurred long before the routine use of sacral anesthesia and, finally, of course, this is not to be construed as my being in favor of exploratory operation in lieu of modern urological study.

Some of these early cases contain records of only a few negative examinations for tubercle bacilli and quite a number only one record. It is to be noted that most of them occurred early in this series before repeated examinations were insisted upon and also in cases on services of other men who stopped looking for tuberculosis just as soon as the cystoscopic diagnosis was made. Some of the cases were in for a day or two and examinations were not made after the first negative reports.

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## DISCUSSION OF PAPERS BY DRs. DEMING AND KRETSCHMER

DR. EDWARD L. KEYES: I was particularly interested in Dr. Deming's comments on rotation of a mobile kidney. I think one gets from his paper a clear idea of the importance of kidney displacement in causing pain by rotation, and I quite agree with what he says on the subject. It is well known that gall bladder disease occasionally occurs in conjunction with descent of the kidney.

But I note that he failed to mention lumbago. I find that pain in the lumbar muscles is a confusing element in the diagnosis of pain due to renal disease. I recently saw a patient who had undergone a number of dilatations of the right ureter, who had a mobile kidney and was said to have a stricture. It was also claimed that there had been infection, which at the time she was first seen by me had cleared up. She had been relieved of her most severe symptoms, but was still complaining of pain, for which her doctor proposed to continue the dilatations. But when I saw her the pain seemed exclusively in the erector spinae muscle. The urine was free from pus; there were no bacteria in it. The pain was ultimately relieved by massage.

Dr. Deming did not make it clear to me what value he attaches to kinks in the redundant ureter. I am inclined to consider them of very little importance. He mentioned a number of cases relieved by dilatation of strictures, but in which the kinks persisted. I suppose it is generally recognized that kinks, as such, along the upper ureter frequently fail to cause obstruction. I do not, of course, include stricture at the upper end of the ureter. It has been my observation that such strictures require resection or some other form of operative relief. I should like to know Dr. Deming's opinion on that point.

I should also like to hear what he thinks of denervation of the kidney, a subject not included in his paper. At a recent meeting of the Pennsylvania State Society, Dr. Hess read a paper dealing with a dozen cases, one-half relieved of pain by denervation. I confess that I have only tried it tentatively, and have no views on the subject.

As far as I am concerned, Dr. Deming's operation is a new one. I have certainly tried, as many of us have, to patch up the fascia about a kidney and make a bed. I was chiefly led to do so by observations of my father, who used to do a quite successful nephropexy by

stuffing wads of gauze underneath and letting the kidney lie on it, gradually removing the gauze and leaving a large scar. The patient remained in bed quite a while, and the same result was obtained as with this new operation, generally speaking. Briefly, I want to compliment Dr. Deming on what to me is the greatest triumph of this operation, i.e., not so much that the kidney is replaced in a very high position, but that it remains fixed and so placed that the lower calyx is drained.

DR. WALTER G. SCHULTE (Salt Lake City): Dr. Kretschmer apparently sees more early and more unilateral cases of renal tuberculosis than we see in Salt Lake City. Most of our cases are referred to us later, when they are bilateral and surgery is not as important as general treatment for tuberculosis. With sunshine and fresh air much can be done in these cases. I have several that are doing very nicely after five to seven years.

I am going to try Dr. Deming's method of anchoring the kidney. I have had very good results in a number of cases that I have suspended because of persistent pain due to faulty drainage.

DR. BENJAMIN S. BARRINGER: The papers of this evening recall to mind that it was Dr. Deming who recently told us how to conserve kidney tissue. I have followed his method of keeping the sutures close to the edge of the kidney and feel, as he outlined last year, that very little parenchyma is destroyed in this way. Now he comes along with another new and very practical operation. I am not exactly clear as to the indications for this operation, but I presume they are pain and impairment of kidney function.

The only really new impulse I have received in the last year on the subject of kidney surgery in tuberculosis was on hearing Dr. Jeck's paper on the administration of spinal anesthesia for these operations. I have since used this method of anesthesia, and believe it is a big step in advance. I would like to know if Dr. Kretschmer has employed it. I recently had a case of kyphosis, where there was no space between the ribs and the pelvis, a tuberculous kidney and a poor heart. The patient would have been a poor risk for a general anesthetic because of the kyphosis alone. A modification of Pitkin's method was used. I took the kidney and the rib out, and feel sure she



would not have done as well with a general anesthetic. I would therefore like to know Dr. Kretschmer's views on the subject.

DR. ALFRED T. OSGOOD: Although I am especially interested in Dr. Deming's operation it has been my experience that nephroptosis is a condition very seldom requiring surgery. It seems that we are finding increasingly few cases in which we are compelled to operate. However, Dr. Deming's careful study, and the way in which the cases were selected, has proved very instructive to me.

DR. A. R. STEVENS: I shall touch briefly on just one or two points in each of these papers.

Apparently Dr. Deming has devised a means of holding up a ptosed kidney without cutting into the kidney or taking sutures through it. This seems to me a step in advance over the ordinary methods if the results are permanent. I wish, however, that he would tell us whether he has made pyelograms in any of his cases as much as two years after this operation.

In the pyelograms which he showed, all of the renal pelvises showed dilatation; and as I recall them, this dilatation extended well down into the corresponding ureters. He said that in about two-thirds of these he was able to make the patients comfortable by ureteral dilatation. I was just wondering how much stress he places on this method of treatment, as many urologists would look for a low ureteral obstruction in these cases. In the roentgenograms of kidneys which had been replaced in the proper position, there still remains, as far as I can make out, quite as marked dilatation of both kidney pelvises and ureters.

Dr. Kretschmer spoke of "excluding a tuberculous focus in the other kidney." I do not see how he can. It seems to me that if we have tuberculosis in one kidney, there is always the possibility of its presence in the other. We can only prove a tuberculous focus which has broken into the renal pelvis, and the possibility of undemonstrable tuberculosis in the so-called good kidney should always be borne in mind, as well as tuberculosis that cannot be proved elsewhere in the body, in advising the individual as to his hygiene and future mode of life.

In those cases where we cannot find the ureter orifices and so cannot catheterize the ureters, there arises the question whether it is not better to do a suprapubic cystotomy, catheterize the ureters and so get direct facts, rather than explore both kidneys and take out the one which merely appears to be the worse.

DR. EDWIN BEER: Dr. Kretschmer has expressed views very similar to those I set forth last Spring when Dr. Medlar discussed the subject of renal tuberculosis before the Section on Genito-Urinary Surgery of the New York Academy of Medicine.

As to Dr. Deming's presentation: My experience with nephropexies is limited, as I feel the indications for this operation are rare. If there is pain and a dilated pelvis with delayed emptying while the patient is in an upright position, it is my opinion that a plastic operation should be performed on this pelvis, with an excision of the redundant wall and a firm fixation of the decapsulated kidney. In many of these cases the ureter is kinked high up in its course by periureteral fixation adhesions. This should be freed at the same time that the kidney is sewed in place. The hammock operations of the past, which have been repeatedly proposed, simulate very closely what Dr. Deming has presented tonight, and I do not believe that fixation of the kidney with extraperitoneal extrarenal supports established with chromic gut sutures will permanently fix the kidney. It is my opinion that a decapsulation and fixation through the cortex and capsule of the kidney with a cigarette drain below the lower pole of the organ will not only be more successful but will obliterate with scar tissue the pocket below the kidney in the perirenal space. A series of late pyelograms following Dr. Deming's modification of the hammock procedure would be valuable testimony in favor of his method of fixation.

As far as the renal tuberculosis problem is concerned, all of us are very much interested in it. Dr. Schulte has said that it is usually bilateral. Medlar and Harris have made the same statement. Experience, however, shows that surgical tuberculosis is unilateral in the great majority of cases, and even at autopsy Rafin reports that over 50 per cent are still unilateral. Dr. Schulte may see only late cases which go on to a fatal termination, but Drs. Medlar and Harris claim that the second kidney gets well following the removal or even without the removal of the one tuberculous organ. Mistakes in interpretation of cystoscopic findings, to my mind, undoubtedly underlie such strange interpretations. Rollier apparently has fallen into the same type of error, and has thought that he has cured bilateral renal tuberculosis by heliotherapy. In most of these cases it is very easy to make a mistake in the diagnosis of bilateral disease when the

disease is definitely unilateral. On one side pus and tubercle bacilli are found in the smear; on the other side the urine in the guinea pig test is positive, the smear usually negative, and a few white cells are found in the centrifuged urine. The significance of the positive guinea pig test on the second side is open to two interpretations: One, that it is a gross contamination from the catheter or by reflux, or due to excretory bacilluria; the other, that it is actually indicative of tuberculosis in the second organ. We have found in studying these cases that 18 per cent of the second kidneys showed positive guinea pig reaction, and Braasch found exactly the same percentage in his series. Still, following nephrectomy of a definitely diseased organ, patients have remained well in a great majority of cases, and subsequent guinea pig studies were negative. In view of what we know about the ease with which specimens can be contaminated unless a most rigid technic is carried out (and even in these circumstances difficulties are encountered), and considering the fact that we know that no definite renal tuberculosis case has been proved clinically as having gotten well, it is fair to assume that Harris, Medlar and Rollier are mistaken, and that nephrectomy of the more diseased organ is not leading to the cure of the second mildly diseased organ. A preponderance of these cases undoubtedly is incorrectly diagnosed, the tuberculosis which leads to the contamination of the urine from the healthy kidney being present either in the one frankly tuberculous kidney or in the genital tract.

Teachings such as these by Medlar, Harris and Rollier, and others, will undoubtedly lead to gross neglect of the patients suffering from renal tuberculosis. A recent paper by Harris in the *British Journal of Surgery* is worth reading, as its logic seems at first blush irrefutable but, on more careful study, most fallacious. He finds in the guinea pig test of the urine of bone and joint cases a high percentage of positive tuberculous bacilluria, whereas frank renal tuberculosis incidence in tuberculous bone and joint cases is less than 1 per cent. From this he concludes that the difference between his positive findings and normal incidences represents the cases that get well spontaneously. To convince any urologist of this, the cystoscopic findings and the ureter specimen examinations would have to be reported in each individual case and the technic of the cystoscopist would have to be above all reproach. Moreover, the

follow-up would have to be over a number of years, and the genital tract would have to be proved non-tuberculous, which is an almost impossible desideratum. Unfortunately, all of Harris' adult cases were males; if he had studied females, I venture to assert that he would have introduced less confusion into this whole domain. Such publications upset the internist, and are harmful to the patient who is suffering from renal tuberculosis.

DR. NATHANIEL P. RATHBUN: With reference to Dr. Deming's presentation, I think some of us remember that twenty-five or thirty years ago there was a tendency to hang up ptosed kidneys, and another period when they gave it up in disgust. Another paper this year on this subject was that of Dr. J. D. Barney, of Boston, who reported many cases. The outstanding point is that these cases must be very carefully selected. Dr. Deming perhaps operates on these cases rather more frequently than I do.

One very important point he has made is that we must be very careful, where there is a ptosed kidney with pain in the side, that we do not overlook some other pathology. He mentions a considerable series relieved without operation. Many cases where the kidney moves all over the abdomen give no symptoms. Also many have kinks and twisted ureters, without symptoms. I think one notable point is that the symptoms complained of are not always due to ptosis. Dr. Deming's operation is very ingenious, indeed. Like Dr. Keyes, I have done such an operation informally, where I tucked the kidney up with any tissue available. I do the old Edebohls operation, plus this little tucking-in process. Dr. Garrity said some years ago that about the best method of doing a nephropexy was to make the usual incision, deliver the kidney, "paw around a bit," replace the kidney and put the patient to bed in the Trendelenburg posture. I am not sure but that he was right.

I was glad to note that Dr. Kretschmer does pyelograms in some of his cases. I do it in all of mine, as I believe it is valuable along the lines Dr. Kretschmer has pointed out. I have had no ill effects, in spite of adverse reports from various clinics, and believe that their difficulties are due to the use of too large catheters, rough handling, etc.

A number of years ago I had a case similar to Israel's famous bifid ureter case. There was a tuberculous lesion around the ureter. Catheterization of this ureter showed crystal-clear urine with no pus or tubercle bacilli. Catheter-

ization on another occasion of this same ureter showed much pus and many tubercle bacilli. At operation we found a bifid ureter with tuberculosis in that segment of the kidney drained by one of the ureters. A pyelogram would have quickly solved this apparent mystery.

There are two classes of cases where diagnosis is extremely difficult. One is that of ulceration in the bladder, tubercle bacilli in the bladder urine, nothing suggestive about either ureter orifice, and no tubercle bacilli from either side, yet where we feel sure there is renal tuberculosis on one side. In such cases I agree with Dr. Kretschmer that we are safe in waiting. Too early operation in renal tuberculosis sometimes does not show as good a result as when we wait a little longer. I do not approve of waiting until we have a marked contraction of the bladder or anything of that sort, but at the same time in early cases there is no indication for hurried operation.

Another type difficult to diagnose is where the bladder is so filled with extensive ulceration that we cannot catheterize either ureter and cannot get roentgenographic evidence that locates the lesion. Ten or twelve years ago I had the temerity to present before one of our national societies the suggestion of opening the bladder and arriving at a diagnosis by catheterizing the ureters, making the point that we could thus get relief from symptoms and give the patient a certain amount of bladder rest which would prepare him for a later nephrectomy, and that following the operation the fistula would probably heal and if it did not heal, the patient probably had the type of bladder with which he would be just as well off with a permanent fistula. I was sat upon so hard that I have never ventured to suggest this again. But I am not sure, nevertheless, but that it might be worthy of consideration.

DR. J. STURDIVANT READ: I would like to emphasize that a ptosed kidney is not always a pathological kidney. A freely movable kidney which does not give symptoms needs no surgery. Frequently symptoms which are thought to be due to movement will entirely disappear for many months after dilatation of ureters. If symptoms persist, then it is right to replace the organ by operation. If the infection in the pelvis of the kidney is cured, many types of operation will hold the kidney in place for at least two years. Dr. Deming's sound and brilliant presentation of a better method of fixation offers hope of a greater percentage of permanent cures.

Dr. Kretschmer has given us a paper replete with keen clinical observations from which he has made deductions helpful to us in the difficult art of diagnosis of obscure tuberculous lesions in the kidneys. In making a diagnosis of renal tuberculosis by means of the roentgen ray, it is well to remember that shadows of calcium salts can be thrown by extrarenal pathology. They are due to inflammatory products, and the condition is not at all peculiar to tuberculosis. We are therefore thrown back on making a diagnosis on delayed function of one kidney, pus, and the presence of tubercle bacilli. If one or two of these findings occur in conjunction with shadows suggestive of calcium deposits in the kidney, then the radiogram is a piece of evidence often of great value.

DR. DANIEL A. SINCLAIR: In considering these papers and the discussion which has followed them, it seems to me that the finding of pus on one side, with tubercle bacilli and the usual bladder symptoms which accompany tuberculosis of the kidney, with a clear urine (even though it does contain a few leucocytes) on the other side, is sufficient justification to remove a diseased kidney, the one showing the tubercle bacilli and pyuria. I would like to ask Dr. Kretschmer how long he waits before he decides to operate upon a frankly diseased kidney.

Dr. Deming's description of his new operation was very interesting, because, as some of the other speakers have said, operations for ptosed kidney have not been regarded as successful; in fact, they have been considered a failure by many. I believe, however, that his new technic is a very good suggestion, and I shall be glad to try it in suitable cases.

DR. ABRAHAM RAVICH: I would like to ask Dr. Deming whether in case of stone in a mobile kidney he would do a nephropexy as a routine measure after the pyelolithotomy, similar to what I believe Dr. Thomas of Philadelphia does; or would he consider the danger of infection from the pyelolithotomy too great to jeopardize this new nephropexy procedure.

DR. CLYDE L. DEMING, Closing: Dr. Keyes has referred to pain due to lumbago as distinguished from that of renal origin. In the cases which I have presented in this paper lumbago was not to be considered, because none of them showed the particular spasm of the erector spinae muscles which is present in this condition. If the patient be examined on the table,

one will see that the side of the involved muscle will stand out prominently in comparison with the other side. Although such an examination was not done in all of these cases, I will admit, it was because there was no history pointing to it.

As to redundant ureters, I hardly know what to say, except to repeat what Dr. Caulk says, that it is no more important than extra length on the end of your nose. It is, as has been pointed out, common after operation; and if tortuous and not kinked, causes little disturbance in most cases. I noticed it and mentioned it in my paper, and I am asking you to look for it and study the condition. There is very little in the literature about it. In fact, I do not know that it is at all significant.

With respect to dilatation of constricted ureteropelvic junctions, my experience has been similar to that of Dr. Keyes. I do not get results. I showed one case where there was a stricture. I could show you many more, but it would mean nothing further than more pictures. In these cases I tried to pick out one of each kind as an illustration. I agree that it is difficult to expect results from dilatation of ureteropelvic junctions, for every time we injure it we get more stenosis and further away from the desired result.

Denervation of the kidney I have done only twice, in cases which did not have a ptosis but had a normal size, functioning kidney with a small and irritable pelvis. Both were relieved of pain. I do not know whether my stand in the matter has been right, but I have not considered denervation in relation to nephroptosis.

Dr. Barringer asked what the indications for nephropexy were. I do not know what all of them are. The cases operated on, however, have been patients totally incapacitated for work and in which it was necessary to get relief from pain. I believe the scope of the operation can be widened.

Dr. Rathbun has mentioned the history of nephropexy. I am fully cognizant of it. One should not run wild with this operation and do it on every kidney he sees, but I would use it only where patients are completely incapacitated and the pain is wholly within the kidney.

Dr. Osgood reports that he sees fewer and fewer of these cases. In the past four years I have seen increasingly more in New Haven.

I did not mean to imply to Dr. Stevens that 55 cases were relieved by dilatation. Only 15 were relieved. Fifteen patients are still hesitating about operative procedure, and I do not

know what has happened to them since I saw them. About one-third were relieved by operation.

Dr. Beer referred to a more fixed operation for the kidney. There are several references in the literature to freeing the kidney and putting it in again, with claims that it stays fixed. These authors claim that there is no pain and no movement after such an operation. Whether this means denervation or a fixed operation is the question. I confess I do not know. Since my operation really does relieve ptosis and pain, why do a more fixed operation?

Dr. Ravich referred to ptotic kidneys with stones. I have only had 2 such cases in which I have done nephropexy. I do not do the operation in such cases as a routine. I do not consider all kidney stone cases as ptosed. I do it only where there is a marked kinking of the ureter, and where the kidney is very low.

I have presented the operation for what it is worth. If we do not get results, there is no harm done to the kidney. We do not strip the capsule, there is no damage to the kidney from sutures and it has the merit of being very simple.

DR. H. L. KRETSCHMER, Closing: I have done but few nephropexies and make my indications for them perhaps unusually rigid. I have seen many patients who had been operated on elsewhere, who still complained of the same symptoms; and I feel exceedingly hesitant about doing an operation that may not give the patient relief. It may be that I am missing a lot and that there are some patients who should be operated upon whom I fail to operate.

With reference to Dr. Barringer's question about spinal anesthesia, I do not use it at the Presbyterian Hospital of Chicago. Personally, I am afraid of it. We feel that in the bladder cases sacral anesthesia or ethylene answers our purpose very well.

The question which kidney is to remain in renal tuberculosis is one that interests all of us, I am sure. At times it is exceedingly difficult to know just how one should interpret a case in which a few leukocytes (or perhaps no leukocytes) are found in the urine, and only a stray tubercle bacillus. As I mentioned in my paper, whenever there is any doubt in my mind, I always wait. I am never in a hurry to operate on these patients, and believe that one should take plenty of time to work out the diagnosis in each individual case to one's own complete satisfaction.

# SPINAL ANESTHESIA: FATALITIES\*

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VERY little is known about the various mechanisms by means of which death may be produced. Perhaps the best evidence regarding this assertion is the comparatively large number of cases in which the cause of death cannot be explained even after careful autopsy. Since under such conditions failure to explain mortality is possible even after careful autopsy examination, how much greater is the likelihood of erring in attributing a mortality to any particular cause if there be no post-mortem examination to check the clinical conclusion! There have been numerous fatalities following operation under spinal anesthesia. Some of these, in all likelihood, were due to the type of anesthetic employed; but a great many others, apparently, bore no relation at all to the anesthesia. Rygh and Bessesen<sup>1</sup> presented a list collected from the recent literature of 215,895 cases operated upon under spinal anesthesia in which there was a total of 75 deaths, a mortality rate of 1 to 3345. In 44,241 of these cases there were 29 deaths of which a fairly satisfactory record was given. Upon reviewing these 29 records, it was found that only 4 of the 29 were attributable to the anesthetic. The other 25 were either moribund before operation or they died 12, 14, 16 to 20 hours after operation, not as a result of the anesthetic, the effect of which long since had worn off, but because of the pathological lesion for which they were operated on. One of the 25, a strong healthy man about to be circumcised died following the spinal puncture without the injection of any anesthetic. The corrected mortality of 4 in 44,241 gave a mortality rate of 1 in 11,060. Even in these 4 deaths (which the authors attributed to spinal anesthesia) the possibility still remains that careful autopsy examination might have laid the cause to some other source.

In comparing the mortality rate of spinal anesthesia with that of any other type it must be remembered that statistics regarding the spinal anesthetic deaths will vary with the experience of those employing this form of anesthesia. It is true, also, that where spinal anesthesia is not used routinely it is selected as the anesthetic of choice because of some contraindication to another form of anesthesia. Furthermore such patients are as a rule of the type classed as poor operative risks. In some of these cases it is quite probable that no operation would have been undertaken under any other form of anesthesia. The hazard of operation was taken, despite the poor surgical risk, only because it was believed that spinal anesthesia offered an increased margin of safety. Likewise, statistics gathered at clinics wherein subarachnoid block is used routinely demonstrate a much lower death rate than those emanating from hospitals where spinal anesthesia is used only occasionally. It must also be remembered that a correct comparison between the mortalities resulting from spinal and other forms of anesthesia, particularly inhalation narcosis, must take into consideration what might perhaps be called remote, late or delayed deaths from the latter type of anesthesia. In the case of spinal anesthesia the mortality is usually dramatic, resulting shortly after the introduction of the anesthetic into the subarachnoid space; whereas, with inhalation anesthesia the mortality may not occur until a considerable time after the completion of the operation. McGrath<sup>2</sup> of the Mayo clinic reported 49,057 ether administrations with no deaths attributable to the anesthetic alone. This was considered to mean no deaths in 49,057 cases. Still, from the same clinic, although not covering the identical period of time, Lundy<sup>3</sup> reported 21 deaths in 600 cases in

\*Crown Heights Hospital, Brooklyn, N. Y. Submitted for publication May 2, 1930.

6 of which he believed ether to be at least partially responsible. These contradictory figures are mentioned to show how statistics may mislead. The value of any statistical study depends less upon the tabulated figures than upon the thoroughness with which all the modifying factors are set forth and discussed. Even when compiled with the utmost care, statistical findings should be subjected to sharp scrutiny and unbiased criticism. Undoubtedly, in a comparatively large number of cases in which operation is done under inhalation narcosis and which result fatally and death is recorded as due to sepsis, infection, pneumonia, shock, uremia, vascular collapse, myocarditis, the fatalities are due to ether anesthesia. Such deaths are not charged against the anesthetic because the patient survives the operative procedure and does not die until some time after the operation has been completed. A death from an anesthetic like ether need not necessarily occur during the time of the administration of the anesthetic. William B. MacNider in 1925<sup>1</sup> demonstrated that ether was quite toxic particularly in older organisms and that the toxicity is shown by an alteration in the alkaline reserve of the blood and that as soon as such alteration occurs there is a reduction in urine formation or the establishment of an anuria. The indictment against ether as a factor in the production of postoperative pneumonic processes is an old one and needs no discussion here.

One cannot help but be impressed with the manner in which spinal anesthesia facilitates abdominal surgical procedures. In patients having obstruction, for instance, operated upon under inhalation anesthesia, the operator causes unnecessary and harmful trauma to the intestines and the peritoneal covering because of a failure to secure as good relaxation as that which is possible under spinal anesthesia. Hence, the increased mortality rate must be laid, at least, in part, to the inadequacy of the anesthetic. If the application of a particular type of anesthetic to a large group of

surgical cases can reduce the surgical mortality by facilitating operative procedures, the beneficial results it seems fair to state would by far outweigh any slight increase in the direct anesthetic mortality that one might presume to exist if one accepts the published statistics without a too critical review of the circumstances. There are, probably, many more spinal deaths than those which have been reported in the literature. Surgeons are more prone to publish their successes than their failures.

Mention has already been made, elsewhere, of the apparent inconsistency regarding the relation of respiratory paralysis to spinal anesthesia.<sup>5</sup> We know, now, that the danger of respiratory failure as a result of the action of the drug upon the medulla consequent to upward diffusion is negligible. One becomes particularly impressed with this upon reading the records of many cases wherein as high as 1200 mg. of novocaine have been injected into the subarachnoid space without any untoward results.<sup>6</sup> With the average dose varying from 100 to 150 mg. injected into the subarachnoid space between the second and third lumbar vertebrae it is difficult to understand how the anesthetic solution could diffuse upward to the medulla in sufficient concentration to produce respiratory paralysis when, under similar circumstances, the use of ten times that amount of anesthetic (in which case the relative amount of upward diffusion would be ten times as great, and therefore much more dangerous) is safe. Another explanation must be sought for deaths under spinal anesthesia. Greater care in observing the phenomena attending fatalities and thorough autopsies will be of inestimable value in dissipating the mysteries which surround these tragic cases.

Few characteristic autopsy findings have been reported after spinal anesthesia deaths.

V. Brunn<sup>7</sup> in an excellent monograph first cited the animal experiments of Van Lier<sup>8</sup> who demonstrated swelling of the

nucleus of the ganglion cells, and wandering towards the periphery after spinal anesthesia. It was shown that these changes were reversible with the cessation of anesthesia. Wassidlo<sup>9</sup> concurred in these findings. Spielmeyer<sup>10</sup> in a patient who died under spinal anesthesia, found definite involvement of the ganglion cells. There was marked chromolysis, dissolution of the nissl bodies and rounding of the cell bodies. There was also dissolution of the nuclear membrane. Spielmeyer concluded, however, that these changes were not directly attributable to the toxic effect of the drug employed (stovaine) but were the sequelae of the circulatory disturbance following the cessation of respiration.

In three patients Spielmeyer observed similar lesions, mainly in the large anterior cells of the spinal cord. In his opinion these lesions correspond to the ones seen in secondary retrograde ganglion destruction. Finding similar lesions after injection of stovaine into animals, he reasoned that the action was primarily a direct toxic effect upon the axon cylinders with the consequent secondary retrograde degeneration of the ganglion cells. In a dog and three monkeys in whom he induced a flaccid paralysis Spielmeyer found widespread lesions of the large anterior horn cells, especially marked in the periphery of the spinal cortical portion. The most intense reaction was present in the nerve fibers of the anterior columns of the lumbar and sacral regions. Evidence of degeneration was seen throughout the entire length of the posterior columns as well as in the posterior roots.

Perhaps one might be able to explain upon this basis the delayed action in abducens paralysis which is encountered at times and leads to a temporary external ocular palsy! The axon cylinder is exposed to the direct toxic action of the injected anesthetic substance. Following the preliminary degeneration possibly thus induced, a secondary degeneration of the ganglion cell results. With marked circula-

tory stasis, however, this course does not take place since the more sensitive ganglion cells are earlier destroyed.

Similar observations made by Klose and Vogt<sup>11</sup> in animals led them to conclude that the action is direct and toxic and not due to circulatory depression.

It seems worth while to consider this topic at greater length and to submit reports of some of the published mortalities so that a proper evaluation may be made. The following are quoted by Rygh and Bessesen.<sup>1</sup>

1. A man, aged sixty, with gangrene of the leg and thigh from a crushing injury, moribund, died fifteen minutes after injection.
2. A man, aged twenty-nine, with avulsion of the arm at the shoulder, shocked and pulseless, was given a high injection and trimming of the injury was attempted. Respiratory failure resulted but he was kept alive six hours with artificial respiration.
3. A debilitated man, aged sixty-five, moribund from typhoid perforation with peritonitis of twenty-four hours' standing, injected when nearly pulseless, died during the operation.
4. An infant, twenty-one months old, with miliary tuberculosis, peritonitis and abscess of the lung, stopped breathing when an attempt was made to find the lung abscess by operation.
5. An obese man, aged fifty-five, with extensive intestinal gangrene and advanced diffuse peritonitis died during operation.
6. A woman, aged forty-five, with diabetes and chronic nephritis, sustained fractures of both femurs, pelvis and several ribs, and died of collapse and shock.
7. A man, aged thirty-five, suffered from advanced tuberculosis with acute urinary retention.

8. A woman, aged eighty-four, had a strangulated femoral hernia of six days' duration and fecal vomiting for two days.

9. A man, aged seventy-two, suffered from strangulated hernia, with fecal vomiting, seventy-two hours prior to operation.

These patients were moribund and in many instances no operation would have been undertaken had it not been for the employment of spinal anesthesia which was considered to give a greater margin of safety. The fatalities were apparently

inevitable, regardless of the type of anesthetic.

10. A man, aged seventy-two, with strangulated hernia, rapid irregular pulse, died two hours after operation.

11. A man, aged sixty-three, non-transportable, with ruptured appendix died on the table.

12. A woman, with ruptured uterus and dead fetus, died a half hour after injection without an operation being undertaken.

13. Patient died of shock.

14. Patient died of shock.

From the reports of these 5 cases it is apparent also that these patients were suffering from shock which in all likelihood contraindicated any operative procedure.

15. A man, aged forty-three, had an enormous empyema with an extensive subcutaneous phlegmon of the chest wall. Cessation of the heart action followed rapid evacuation of pus.

16. A man, middle-aged, had a sudden cessation of the heart when evacuation of a large amount of pus from the thoracic cavity was attempted.

17. A woman, aged fifty-two, had a rib resected and three pints of pus evacuated.

It is difficult to explain the results in these cases. The authors quoted believe that the nerves of respiration and vascular control which are largely centered in the thoracic and cervical regions offer contraindications to operations above the diaphragm. Death is blamed upon the rapid evacuation of the pus in Cases 15 and 16. In our experience with empyema thoracis there is no contraindication to the rapid emptying of the chest cavities. Indeed, our method consists of the introduction of a trochar into the abscess cavity and the aspiration of the pus under strong suction.

18. A woman aged sixty, had a gall bladder operation with peritonitis.

19. An obese man of fifty died following a gall bladder operation with peritonitis.

One of the chief factors in the postoperative treatment of acute peritonitis is Fowler's position. To employ spinal anesthesia with safety, it is necessary that the head of the

patient be lowered during the operation and for three hours following the injection. These positions are incompatible. On this account, in a severe peritoneal infection, where Fowler's position is a constant desideratum, spinal anesthesia would be inadvisable.

According to the authors' comments it would seem that these patients died subsequent to the completion of the operation after having been placed in Fowler's position because they were not in Trendelenburg posture. Unfortunately, this point is not quite clear. It seems unnecessary to state that no matter how severe the infection, if operation has been performed under spinal anesthesia the Trendelenburg position should be maintained until the anesthesia has worn off.

20. A patient received 9.5 grains of procaine, remained living while in Trendelenburg position, but died when brought to level.

21. A patient received 9.5 grains of procaine remained living while in Trendelenburg position, but died when brought to a level.

The authors in their comments claim that the results were toxic deaths due to overdosage but it seems quite clear that the explanation for the fatalities was in the change of the patients' position from that of the Trendelenburg to the horizontal.

22. An old man died from injection of butyn.

23. Toxic death due to stovain.

24. Toxic death due to stovain.

Butyn is more toxic than cocaine; and both are too toxic for spinal or sacral anesthesia. Deaver condemns stovain for spinal anesthesia. [Authors' comment.]

25. An eclamptic pregnant woman to be operated by cesarian section received the spinal injection and died during a convulsion with cyanosis, apparently from asphyxia.

Clinically this is an eclamptic death. [Authors' comment.]

26. A strong, healthy man about to be circumcised, died following spinal puncture without the injection of any anesthetic.

27. A man, aged forty-three, with an extensive bilateral fibroid tuberculosis and subacute tuberculous laryngitis suffered from a severe dysphagia especially for fluids. The spine was



drained of 7.5 c.c. of fluid in a sitting posture and then 1.25 grains of apothecin dissolved in distilled water injected. The patient was placed with his head on a pillow and developed immediate fatal respiratory paralysis.

This is an excellent example of what may be expected after spinal anesthesia if the Trendelenburg posture is not employed.

28. A young woman being operated upon for retroversion of the uterus, developed collapse, was revived twice with adrenalin solution, but finally died when this stimulus was attempted for third time, four and half hours after operation.

29. A woman, operated on for cyst of the ovary, died when the cyst was punctured, apparently of collapse.

These cases are copied to exemplify our statement that the material available for judgment of the mechanism by which death occurs is inadequate, too meager really, to allow of any accuracy. In the discussion of the value of spinal anesthesia before the Society of Surgery in Paris in 1923 and 1924, 20,267 cases were recorded and published in which there were 10 deaths.

These cases were quoted and discussed by Sylva and are tabulated below.<sup>12</sup>

	Spinal Anesthetics	Deaths
Duverguey	2256	1
Jonessco	5481	0
Dujarier	4000	4
Cauchois	500	1
Plission and Clavelin	1011	0
Lepoutre	500	0
Leclerc	300	0
Labey	680	3
Sauve	1000	0
Chifolian	1000	0
Riche	3539	1

*Duverguey's Case:* This treats of a patient with an old abscess of the lung. He made an injection of scopolamine, then removed 10 to 15 c.c. of cerebrospinal fluid, committed barbotage and injected all cocaine-adrenalin. The patient died in coma with temperature of 40°, eighteen hours after the operation. Details for duly estimating it are lacking, but the fact of being treated for an abscess of the lung, that he died with a temperature of 40 makes one suspect that there could have been an infection.

The lapse of eighteen hours after the operation is certainly sufficient to eliminate this case as a death to be charged against spinal anesthesia.

*Dujarier's Cases:* He had 4 deaths. He gives no details, states that they died of asphyxia, and adds: "I had 4 cases of death due to operations, but always in cancer, cachexia or occlusion. I never had cases of death in young people without tumors. It would seem that these cases cannot be charged to spinal anesthesia."

*Case of Cauchois:* A woman, fifty years old, operated on urgently for a complicated fracture of her leg; dead at the beginning of her operation. He does not give details and attributes the death to the fact that he always uses the solution prepared by Carrion, and this time he used a solution prepared in the pharmacy of the hospital.

*Labey's Cases:* A woman treated for a long time for a very serious angiocholitis. He says: "I do not think this death can be charged to spinal anesthesia; that it probably would have occurred, I believe, with another anesthesia."

Second: Cancer of the stomach, cachectic, died in a faint. He declared that "the sick woman would not have tolerated general anesthesia."

Third: Hysterectomy on account of an old hematocele and cyst of the ovaries. Unconsciousness at the time of suturing. He noted that the solution had a yellow color; it was, consequently defective.

*Riche's Case:* Dead on account of meningitis.

An analysis of these reported deaths shows that the first case of Duverguey is unquestionably not due to spinal anesthesia. The next 4 cases of Dujarier whose deaths are taken from a series of 4000 were apparently extremely bad risks. The mere fact that he himself excuses the anesthesia from responsibility should not be taken too seriously but his statement that he never had cases of death in young people without tumors is of importance because it helps to give a clearer picture of the condition of the patient who died. The details in the case cited by Cauchois are too meager to deserve any other comment beyond the one that there is no evidence that the solution was not a good one. In Labey's

cases apparently the first two were very seriously ill and there is as much likelihood that they died of the pathological lesion for which they were operated on as for any other reason. The third case of his may, perhaps, be charged against a defective solution.

Silva reviews also the following mortalities.

Two cases of André were published by Schevassi. One, a man of sixty years, suffering from disorder of the prostate, albumin in the urine, with serious retention, dead in a swoon. He does not describe the technic. The other, a man seventy-six years old, suffering from prostatic disease, albuminuric, with complete retention. Dead three hours after the prostatectomy. He does not give the technic. Lepoutre added the fatality in a man, quite fat, with two large herniae, with glucose and acetone in the urine. Lepoutre withdrew 10 c.c. of cerebrospinal fluid, injected 0.1 gm. of syncaïne and committed "barbotage." The patient died eight days later with jaundice.

We do not see the responsibility of spinal anesthesia.

Sauve reported 3 cases:

An advanced cancer of the uterus. A woman with intestinal occlusion, and a hysterectomy with salpingitis, dead ten hours later.

He did not give details, but from the explanation one sees that they were cases where the responsibility of spinal anesthesia was quite problematical and extremely doubtful.

Auvray published the following case:

A woman, seventy years old, always in poor health, bronchitis during the winter, a large cyst of the ovary. Difficult breathing appeared, then a sense of suffocation, interrupted speech and a pulse rate of 120. The necessity to administer digitalis arose. A sick woman, notably lean with an accentuated ovarian cachexia. [Auvray considered general anesthesia highly dangerous, and employed spinal anesthesia, withdrawing fluid and injecting 0.12 gm. of novocaine.] The patient was dead five minutes after the injection.

Faure called attention to a man operated on after three strangulated herniae, who died on

the following day with black vomiting. Faure stated that he did not attribute the death to spinal anesthesia.

Barthelemy reported the case of a woman, sixty years old, with a strangulated umbilical hernia and chronic tracheitis that contraindicated general anesthesia by ether or chloroform. He induced spinal anesthesia with 0.12 gm. of novocaine after withdrawing 25 c.c. of fluid. Died.

The same man presented the case of a boy, nineteen years old, with an inguinal hernia; withdrawal of 25 c.c. of cerebrospinal fluid, injection of 0.12 gm. of novocaine and dead in two months from meningitis.

*It is seen from these additional cases that the reports furnish insufficient data for drawing any valuable conclusions.*

Brun<sup>13</sup> reported 6147 spinal anesthetics in the hospital Sadiki from 1919 to 1928 with 3 deaths. One was in a man of seventy years, who was cachectic and who was operated upon for an extravasation of urine. The second was for a strangulated hernia in an old woman, the strangulation having existed six days. The third was an amputation of the thigh in a sixteen-day old child because of a spreading gangrene following the application of a plaster cast for a fractured femur.

His own commentary is to the effect that the gravity of these cases did not permit the death to be charged to the spinal anesthetic.

Four cases in which mortalities resulted were published by us in the AMERICAN JOURNAL OF SURGERY in 1928. These cases and several others which we shall add we feel should be incorporated in this work.

One patient who expired on the table was a man of sixty-seven operated upon forty-eight hours after the onset of acute intestinal obstruction which operation disclosed to be due to an annular carcinoma of the cecum. He was so dehydrated and so highly toxic that only with reluctance and because of the minimizing effect of spinal anesthesia on operative trauma was the operation undertaken. Another death occurred in a highly toxic diabetic patient of sixty-two with a rapidly spreading gangrene of the foot and leg. During the course of a guillotine operation at the middle third of

the thigh, his pulse suddenly became imperceptible and stimulation failed to restore the circulation. Another fatality occurred in a child of six. She had been treated with ice-bags at home for a supposed appendicitis and the abdomen was sectioned three days after the onset of the illness on a provisional diagnosis of obstruction. At this time, she was thoroughly dehydrated, highly toxic and but a degree removed from death. At operation, a Meckel's diverticulum was found to have caused complete obstruction and gangrene of about 4 ft. of small intestine. During the resection, her life ebbed out. The fourth death occurred in a woman aged fifty-two who had been bedridden for three years because of a severe myocarditis with several attacks of decompensation and who came to operation for a suppurative appendicitis with localized suppurative peritonitis of three days' duration. Appendectomy was done, drainage was instituted and the wound closed. After the dressings were applied, and as the patient was about to be transferred to the stretcher for transportation from the operating room, she ceased to breathe suddenly and the heart beat became imperceptible. The wound was opened quickly and transdiaphragmatic massage of the heart instituted. Intracardiac stimulation and artificial respiration failed, however, to prevent death.

Since that time, we have had several other cases which we feel should be added to this list and of which we shall write in as much detail as possible.

The first was one of carcinoma of the breast which was operated upon under spinal anesthesia (200 mg. of neocaine dissolved in 8 c.c. of cerebrospinal fluid) the operation lasting forty-five minutes. While the skin was being closed, for no demonstrable reason, the patient ceased breathing. A rather exhaustive autopsy failed to reveal any reason for the fatality. No brain examination was made because permission could not be secured. This patient was forty-nine years of age and apparently in good health otherwise. Preoperative study resulted in her classification as a good operative risk. Another patient, thirty-seven years of age, with a well marked bronchial asthma was operated upon under spinal anesthesia for prolapse of the uterus. She was given 150 mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid, injected between the second and third lumbar verte-

brae, and ceased to breathe within ten minutes without any warning, whatsoever. Efforts at resuscitation failed. No autopsy was obtainable in this case and this is one of the types in which the mortality might be directly attributable to spinal anesthesia.

Under these circumstances, however, the question can rightfully be asked "what was the mechanism of death?" Since the amount of the anesthetic injected was no greater than that employed in thousands of other cases, the injection having been made at the same site, the same amount of solvent having been used, how, then, can the mortality be attributed to spinal anesthesia in view of the large number of cases in which much greater quantities (as high as 1200 mg.) were injected into the subarachnoid space without fatalities?

Another case of an extensive alveolar carcinoma involving the entire left breast in a woman of fifty-seven who claimed she had the lesion for thirteen years and in whom there was a large axillary metastatic focus but without any other demonstrable lesion was operated with the endotherm under spinal anesthesia. This patient received 300 mg. of neocaine dissolved in 10 c.c. of cerebrospinal fluid. Ten minutes after the operation was begun, respirations ceased. Artificial respiration was maintained and an intracardiac injection of adrenalin was given about one minute and one-half after respiration had apparently ceased, and the pulse and heart beat had become feeble. Within two and one-half minutes respirations began spontaneously. Three days postoperatively, she developed a severe infection of the wound with high temperature, gangrene and sloughing and expired on the fifth day after operation.

This is quite evidently a case in which the mortality was not due to spinal anesthesia but rather to the severity of the type of infection.

Another patient, a female, aged forty-eight, had multiple large fibroids of the uterus for which she was operated upon under spinal anesthesia, 150 mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid being injected between the second and third lumbar vertebrae. The median lower abdominal incision

was made and the fibroids inspected. In the right lower quadrant a retroperitoneal mass was distinguished as coming from the lower pole of the right kidney which was prolapsed. The peritoneum to the outer side of the cecum was opened, a solitary cyst of the lower pole of the right kidney was excised, and the peritoneum closed. A hysterectomy and appendectomy were then done. Before the abdomen was closed, the gall bladder was palpated and was found to contain a large number of calculi. The lower incision was closed and an upper abdominal incision made. About fifty-three minutes had elapsed from the time of administration of the anesthetic and, while the upper abdomen was being incised, the patient complained of considerable pain. It was realized that the cholecystectomy could not be performed unless some additional anesthesia were given. Instead of our rolling the patient over and giving another spinal anesthetic as would have been done had the skin incision not already been made, gas-oxygen and ether were administered. When the patient was anesthetized, the gall bladder was quickly removed. As the closure of the peritoneum was begun it was noticed that respiration had ceased. Artificial respiration was instituted and intracardiac adrenalin stimulation given. After a lapse of five minutes the patient resumed breathing and shortly afterward was returned to her bed. She did not, however, regain consciousness and expired thirty-six hours after the operation.

It would seem that this fatality might have been due to a period of cerebral anemia lasting approximately five minutes as a result of which there was sufficient degeneration or injury to the brain tissue from which recovery was impossible. *The cessation of respiration which occurred in this case came after the spinal anesthesia had worn off.* It is impossible for the authors to see how this fatality could in any way be blamed upon spinal anesthesia. This case, however, is emphasized because of the similarity to the one which preceded it, namely the carcinoma of the breast case. Had the situation been reversed and cessation of respiration in the gall bladder case occurred early in the operation, the temptation to indict the spinal anesthetic would have been strong. Under the existing

circumstances, however, if the anesthetic were at fault, it was gas-oxygen-ether and not spinal anesthesia. It is easy to see how the etiological factors in both these 2 last cases could be mistaken one for the other. Even with the finest detailed description, unless chemical evidence of the activity of the drug upon the vital centers be obtainable, the scientific proof of the mechanism by which death is occasioned cannot be determined beyond a doubt.

Another case is that of a tonsillectomy in a boy of nine years of age operated upon under spinal anesthesia. He was given 150 mg. of neocaine dissolved in 6 c.c. of cerebrospinal fluid. The injection was made between the second and third lumbar vertebrae. Satisfactory anesthesia of the entire body resulted. The operation was completed rapidly and the patient returned to bed. About ten minutes after he was placed in bed, oozing from one of the tonsillar beds became brisk. In order to facilitate the expectoration of blood, a new nurse (unacquainted with the details of technic necessary for the maintenance of safety in patients who have been operated upon under spinal anesthesia) sat him upright in bed. He remained in the sitting position for about two one-half minutes and then ceased to breathe. Efforts at resuscitation failed to revive him. This, unquestionably, was an anesthetic death due to spinal anesthesia. It is believed that this death, however, could have been avoided had the patient been kept in the Trendelenburg posture or at least in a horizontal position.

In another case a male fifty years of age, obese and emphysematous, operated under spinal anesthesia for a perforated appendix with peritonitis developed paralytic ileus. On the fourth day postoperatively, because of continued vomiting not controlled by lavage and paralytic ileus which did not respond to eserin, pituitin, enemata and hypertonic sodium chloride intravenously, it was decided to try to stimulate intestinal peristalsis by spinal anesthesia. One hundred and fifty mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid were injected at the usual level. The patient was immediately placed in Trendelenburg position. One minute later, he became cyanotic, began vomiting so copiously that he aspirated a large quantity of the vomitus and expired. At autopsy the lungs were found to be water-logged with the brackish vomitus.

A young woman in the early thirties, eight months pregnant, in whom an operative delivery was decided upon because of hemorrhage from a central placenta previa was given 150 mg. of neocaine in the usual manner. After she was placed in the Trendelenberg position, the operator manually dilated the vagina and cervix and then plunged his hand through the placenta to do a version. A foot was grasped and as the rotation was begun it was noticed that the patient became cyanotic, ceased to breathe, had dilated pupils and shortly thereafter lost vascular pulsations. A living child was delivered but the mother died. An autopsy was not obtainable.

Two of these deaths (the tonsillectomy and obstetric cases) do not belong in our operative series but were included because the anesthetics were administered by us and we were present to record the phenomena attending the fatal outcome. The others, 9 in number, were the total number of deaths which might have been attributed to spinal anesthesia out of a total of almost 6000 cases.

Aside from these cases, we have had no fatalities which even remotely might have been considered as due to the anesthesia. It is our feeling in analysing these cases that the tonsillectomy death was an anesthetic death directly due to the failure to observe the necessary precautions. Regarding the others, despite the fact that in some cases autopsies were performed and as many details gathered as possible, there was no definite scientific evidence indicting spinal anesthesia. These mortalities could easily have been duplicated under any other form of anesthesia and perhaps much more easily in several of the cases cited. On the other side of the balance may be placed a large number of cases of patients operated on under spinal anesthesia that resulted favorably. These are cases which in the judgment of the operator certainly could not have terminated favorably had they been operated upon under any other form of anesthesia. This is especially true of cases of intestinal obstruction with considerable toxemia. The reduction in the surgical mortality

rate by the use of an anesthetic which diminishes trauma and diminishes shock, increases peristaltic movement and thus gives an additional margin of safety for the patient, undoubtedly saves many lives. This additional safety factor in so large a number of cases far outweighs the possible slight increase in death by direct anesthetic mortality.

Of our total number of almost 6000 general surgical cases there were only 6 deaths on the operating table. All these received spinal anesthesia, and are included in the 9 listed as possible anesthetic deaths. How many "table" mortalities a year does the average active surgical service have under inhalation anesthesia? In this same series of almost 6000 cases, how many deaths would have occurred on the operating table under any other form of anesthesia? How much greater would the total mortality have been under any other form of anesthesia? The answers to all these questions cannot at present be determined with scientific exactitude because no parallel control series is possible. The nearest approach to an answer of value is the clinical impression of the individual operator with an extensive experience.

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# ADHESIONS OF THE SMALL INTESTINE\*

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IN this paper we wish to direct attention to the possibility of x-ray diagnosis and operative correction of adhesions

the gut to some neighboring organ or to the abdominal wall. This type may produce no symptoms. However, it forms a trap that



FIG. 1. A typical pattern of small intestine following appendectomy, of type that produces no symptoms. Five and one-half hour observation.



FIG. 2. Another case producing atypical pattern that followed appendectomy. Not to be regarded as pathological.

involving the small intestine. The growing interest in roentgen diagnosis of small intestinal states is attested by the papers of Kornblum<sup>1</sup> and Ritvo.<sup>2</sup> The technic is described in Soper's<sup>3</sup> recent article.

Adhesions may be divided into 3 classes. The vast majority are postoperative in character but some are produced by former inflammatory processes. We have designated the usual adhesions that follow appendectomy as Grade 1. In this type the coils of the terminal ileum are matted together; i.e., adherent to each other. No symptoms are produced by this form.

In adhesions of Grade 2 one or more bands are formed which attach a coil of

may catch a loop of the bowel and produce acute obstruction. Often a patient gives a history of several attacks of partial obstruction, with complete absence of symptoms between the attacks. The most careful x-ray examination may fail to disclose these bands, but the alert observer will usually find atypical dilated coils.

Adhesions of Grade 3 form definite bands which bind down the intestine and form a partial stenosis of the lumen and interfere with function, as illustrated by the adhesive bands that constrict the terminal ileum. This type is more easily demonstrated by roentgen examination. The symptoms are usually dull pain located

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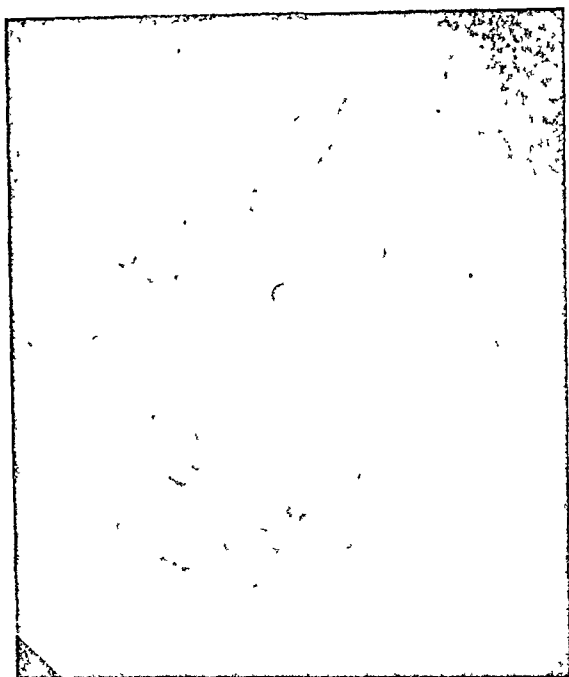


FIG. 3. Atypical pattern of small intestine following appendectomy not regarded as pathological. Patient, however, developed definite attacks of partial obstruction and operation disclosed definite adhesive bands binding down terminal ileum. This case is of extreme importance inasmuch as it illustrates that we are justified in operating on basis of history alone when no real x-ray evidence is presented.

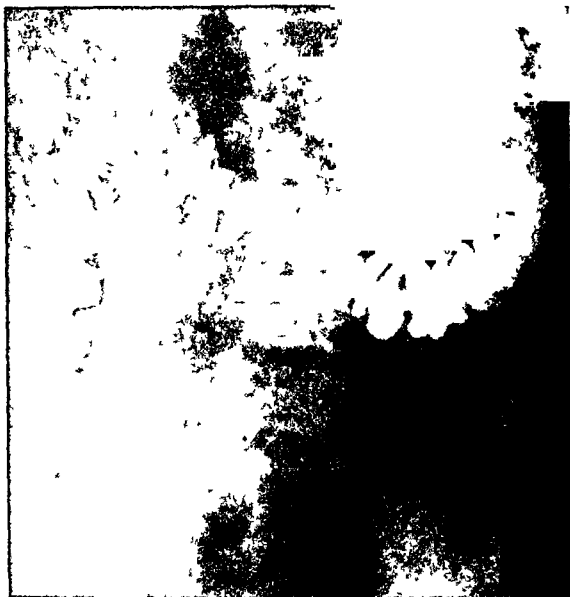


FIG. 4. Twenty-four hour ileal stasis. Young woman who had several attacks of partial obstruction following operation for gallstones one year ago. Operation strongly advised but declined until acute complete obstruction had occurred necessitating immediate surgery. Strong fibrous bands located in ileum. Exitus.

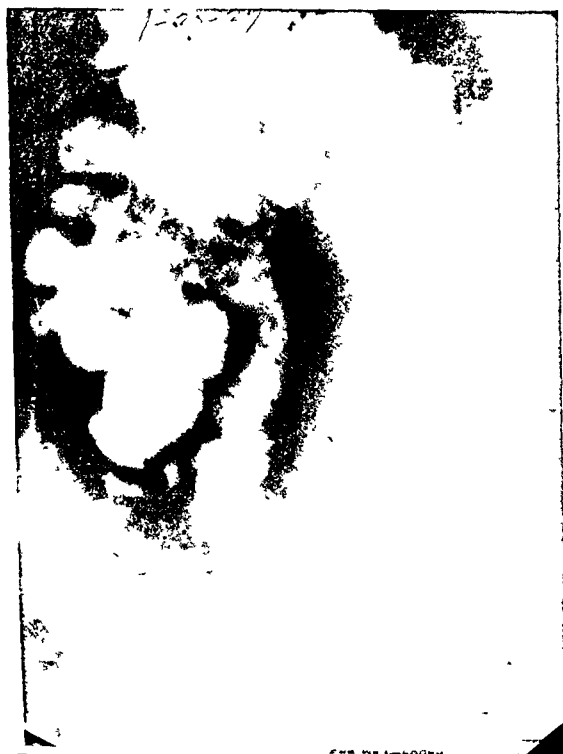


FIG. 5. Twenty-four hour stasis of terminal ileum following attacks of appendicitis. Operation disclosed strong band binding down appendix and ileum at ileocecal valve.



FIG. 6. Partial obstruction of lower ileum due to Meckel's diverticulum. Operation disclosed several loops of ileum attached to diverticulum. Male, aged nineteen years, a chronic invalid for past two years. He was much emaciated. Note dilatation and sacculatation of ileum on six-hour films, also gastric motor delay. Now three years after operation and he has remained in perfect health.



FIG. 7. Patient female, aged fifty-two, had exploratory abdominal section in 1925 with negative results. Came under our observation in 1927. Atypical loops observed on six-hour film. Patient had suffered from attacks of partial intestinal obstruction since operation. Second operation revealed a band about 3 ft. from ileocecal junction. Good operative recovery. (Lower arrow marks narrowing corresponding to exact location of band.)



FIG. 8. Same patient as in Figure 7. Normal intestinal loops three months after operation.

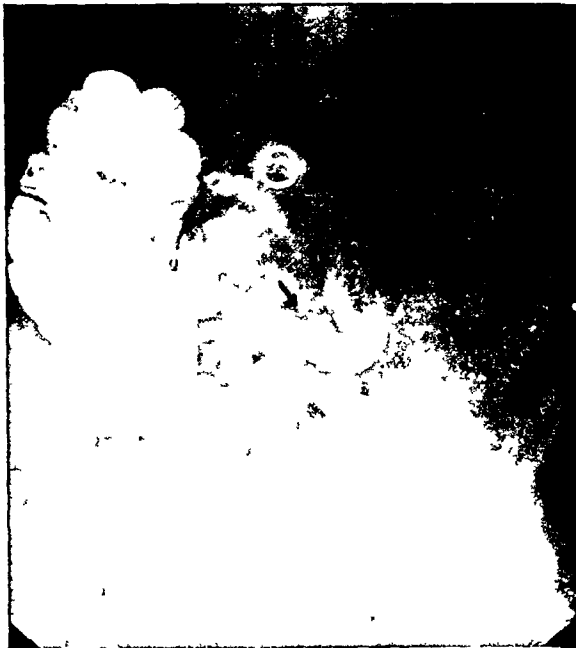


FIG. 9. Adhesive bands involving lower ileum. Atypical loops were best seen at five and a half hour observation. There was no twenty-four hour ileal stasis. Operation disclosed a pathological appendix adhering to terminal ileum in such a way as to cause a kinking which resulted in partial obstruction of bowel. This patient, a female, aged forty years, gave a history of attacks of appendicitis as well as attacks of partial obstruction.



FIG. 10. Same patient as in Figure 9. Film secured six weeks after operation. Normal intestinal loops. Patient made perfect recovery and has had no symptoms for past two years.



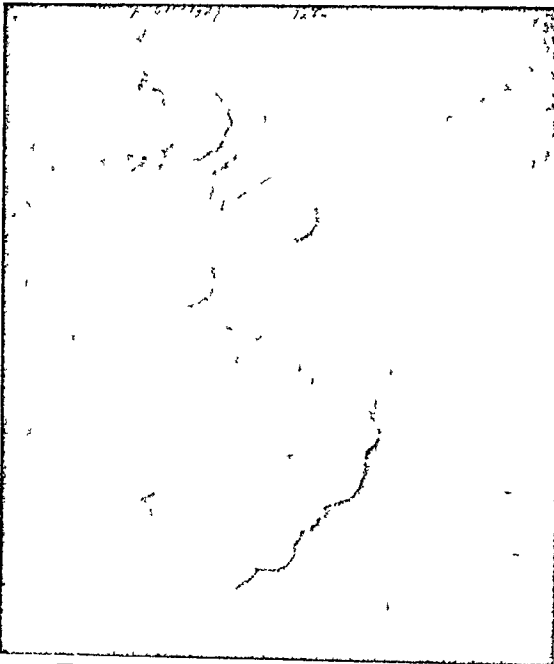


FIG. 11. Two years ago this patient, a robust young man was operated upon for appendicitis. He complained of pain located at upper part of abdominal scar corresponding to dilated loop depicted on film. No history of obstruction. Second operation disclosed an adhesive band binding down a loop of ileum. Perfect recovery.

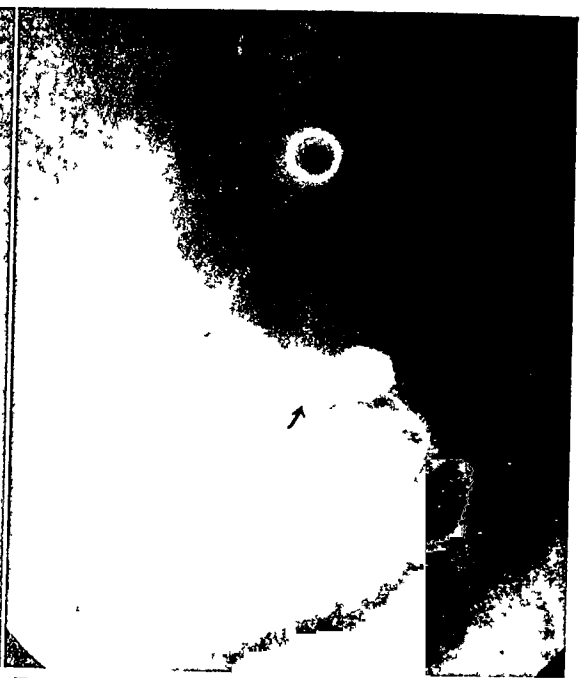


FIG. 12. Atypical loops which apparently indicated adhesions involving terminal ileum. At operation no adhesions found involving small intestine but a strong band caused partial stenosis of ascending colon at junction with cecum. Case of Mill's recoil phenomenon.



FIG. 13. One year after appendectomy. Patient had succession of attacks of partial obstruction. At operation firm fibrous bands bound down terminal ileum. Good recovery.

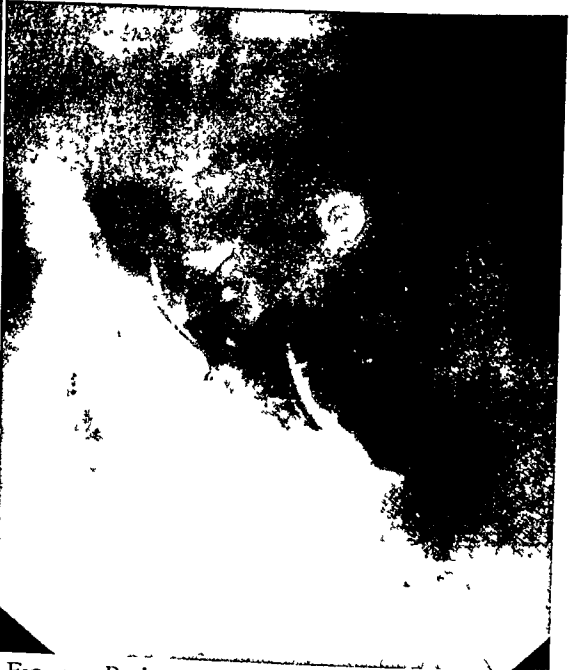


FIG. 14. Patient, female, aged thirty, operated upon three years ago for pelvic condition. Again one year later for adhesions. She had several attacks of partial obstruction and because of her complaints and good general condition she was rated as postoperative neurotic. This film secured at six and one-half hour period. Third operation disclosed four definite adhesive bands of Grade 3. One year after operation and she is free from symptoms.



FIG. 15. These atypical patterns secured in patient suffering from attack of acute cholecystitis. At operation no adhesions were found. Atypical loops probably resulted from general disturbance in gastrointestinal motility induced by severe pain. One must not judge small intestinal patterns during abdominal pain or migraine attack.



FIG. 16. Patient had uterine suspension operation ten years ago. Acute intestinal obstruction occurred Nov. 9, 1929. Operation disclosed strong band binding down the terminal ileum. Loop tremendously distended and congested; no resection done. Dec. 27, 1929 when patient was having mild attacks of acute obstruction. Final good function followed mild laxatives and smooth diet.

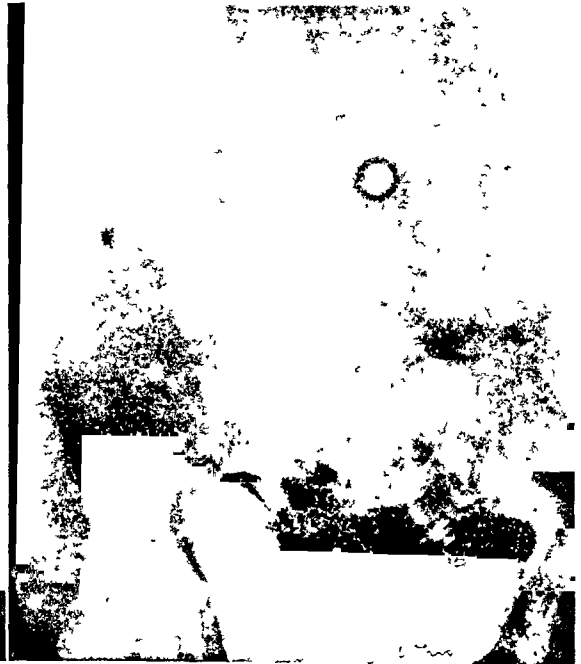


FIG. 17. Same patient as Figure 16. Review of her history disclosed symptoms of dysfunction of small intestine. This film was made three years ago and reveals atypical loops which were not recognized at that time.

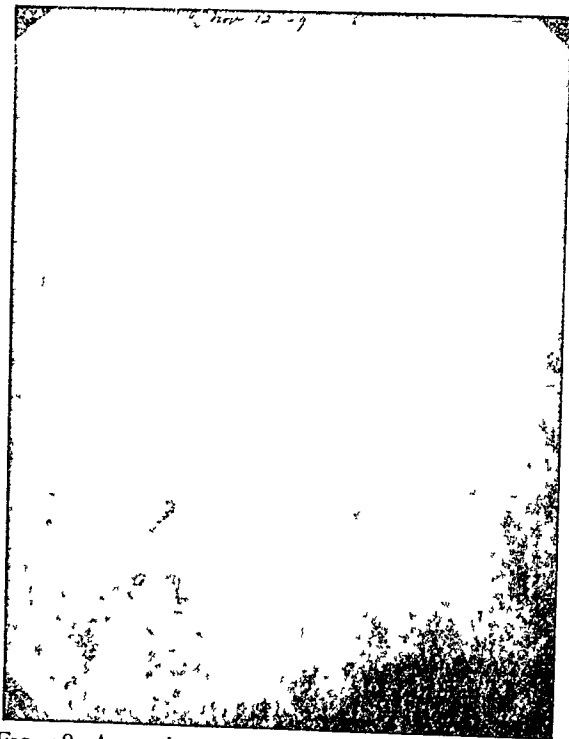


FIG. 18. Appendix operation two years ago. Colicky pains, nausea and vomiting attacks since. Roentgen examination showed atypical duodenal pattern as barium was leaving stomach. At operation duodenal loop found to be adherent to abdominal wall. Good recovery.

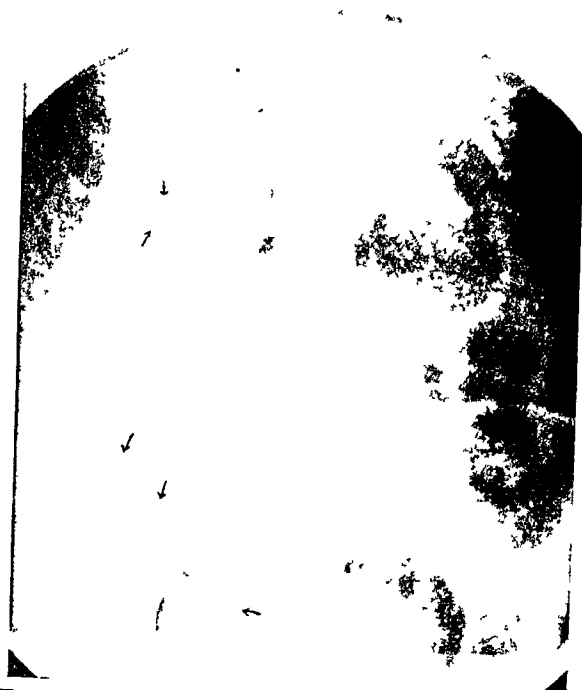


FIG. 19 This film was secured prior to the operation in patient aged sixty-five. Had suffered from duodenal-ulcer and gallstones but refused surgery. Stones can be seen in upper right quadrant. The gallstone attacks always atypical in character. She suddenly developed symptoms of very acute obstruction and was operated upon. Lower dilated loop designated by arrow found to be jejunum. Bowel was almost gangrenous but circulation returned and resection was not done. Good recovery. Her original operation was for uterine suspension twenty years ago.



FIG. 20. In reviewing her history we can read partial obstruction. This six-hour film taken in 1924 with gastric motor insufficiency, duodenal cap deformity and atypical loops explains many of her attacks which were erroneously attributed to gallstones.



FIG. 21. This film shows a tremendous distension of entire small intestine taken just before operation. General peritonitis present. No obstruction. It is obviously characteristic of ileus.



FIG. 22. Patient female, aged fifty-one. Entered St. Luke's Hospital with symptoms of acute intestinal obstruction April 2, 1929. Eighteen months ago her kidney was removed and peritonitis developed. This film was secured and operation advised but declined. She eventually recovered from attack, but atypical pattern remains and doubtless other attacks will occur.

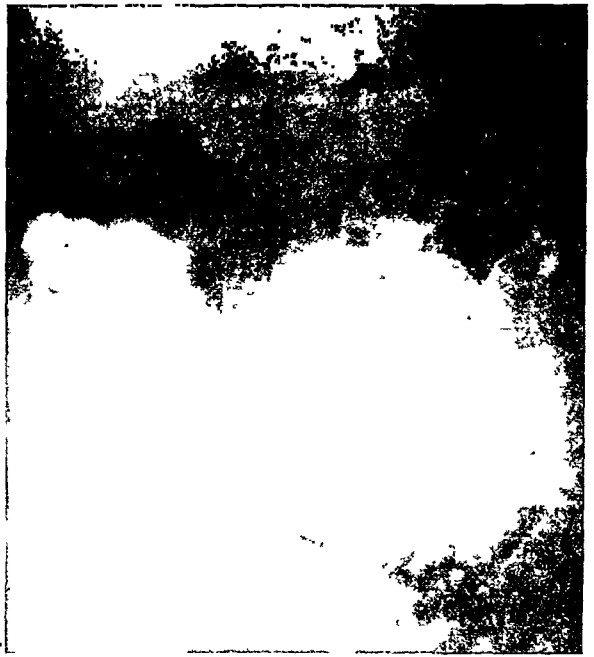


FIG. 23. This is position of small intestine assumed in postoperative hernia following operation for pus appendix one year ago. No obstructive symptoms. No operation advised.



FIG. 24. Atypical loops occurring in case of achylia gastrica with diarrhea. One should be extremely careful of making a diagnosis of atypical patterns in diarrhea conditions.

in the region of the constriction, intermittent in character, often nausea and anorexia. A history of partial attacks of obstruction is usually obtained.

It is obvious that adhesions of all 3 types may exist in the same patient. We present x-ray films illustrating the various types. The attached legends give an epitome of the case history.

We emphasize that operative interference is not advised unless the clinical history is clear. Concise statements may be difficult to elicit in a psychotic individual, but we are confident that this procedure will rescue many patients who are diagnosed as suffering from a postoperative neurosis.

#### OPERATIVE TECHNIC

Spinal anesthesia is of extreme importance, inasmuch as it produces perfect relaxation of the intestine and the collapsed gut is easily handled, thus preventing trauma.

At operation the terminal ileum is identified near the ileocecal valve and it is carefully followed back toward the jejunum and the abnormal attachments dissected free. Any eviscerated loops are carefully covered with moist gauze sponges made from cotton of fine weave. The bowel is always manipulated with the utmost gentleness and respect for its property of producing an inflammatory exudate which results in agglutination of the peritoneal surfaces of the loops. The abdomen is then closed without drainage, care being taken to place the omentum between the intestine and the abdominal wall to prevent them from becoming adherent.

The postoperative treatment is of extreme importance. We must avoid every thing that might incite peristaltic movement of the small intestine. During the first seventy-two hours after operation

the following rules must be rigidly enforced.

1. No food or water is given by mouth. Frequently moisten the tongue and lips with cold water.

2. The patient is sustained by the free use of intravenous glucose and saline solution.

3. No vomiting is permitted. The Levin intranasal catheter is kept in the stomach and the contents syphoned until all danger from accumulation of gastric secretion is over.

4. No enema or passage of the colon tube is permitted.

5. No laxative is given.

The patient is kept under the constant influence of morphine. It is given hypodermatically by the overlapping method, i.e., every four to six hours in doses sufficient to produce mental calm and physical rest. The dosage will vary from one-twelfth to one-fourth grain. Care must be exercised that the patient does not emerge from the morphia influence until the seventy-two hour period has elapsed. After this time the usual symptomatic treatment is employed.

#### CONCLUSIONS

1. Adhesions of the small intestine that give symptoms can as a rule be detected by careful roentgen examination.

3. Relief may be obtained by surgical operation and strict observance of a post-operative regime.

3. X-ray films are shown illustrating the diagnosis and differential diagnosis of adhesions, with abstract of case records.

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# PATHOLOGICAL FRACTURES IN PRIMARY BONE TUMORS OF THE EXTREMITIES\*

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**P**ATHOLOGICAL fracture is a frequent complication of a primary bone tumor of the long bones. In many cases fracture is the first symptom that leads the patient to seek medical advice. And yet aside from isolated case reports and a few brief communications, there is a striking lack of recent literature on this important subject.

The earliest exhaustive work on pathological fractures is that of von Brüns in his "*Lehre von den Knochenbrüchen*" published in 1886. Grunert reviewed the literature from 1886 to 1904 and his monograph is excellent; his classification of pathological fractures is comprehensive; and search of the recent literature fails to disclose any contributions that compare with his work, although Eisendrath in "*Keen's Surgery*" has an excellent survey of the subject.

Grunert emphasizes the rarity of pathological fractures due to metastatic sarcoma; he found but two examples in the literature. He mentions the fact, which is brought out by our series, that fracture is frequently the first thing that makes us appreciate a long-standing disease of the bony system. He quotes von Burckhardt who maintains that in cases of pain in the hip of unexplained etiology followed later by fracture one should be wary of assuming that the condition is a disturbance of the nervous system.

Grunert wisely observes that there are too many examples in the literature where fracture is the first sign of the disease and that an important indication as to the nature of the disease is afforded by the fact that as a rule a pathological fracture when the result of a malignant tumor rarely unites.

Grunert has the following to say regarding union of pathological fracture due to bone sarcoma:

As Cornil and Ranvier have shown, new osteoid tissue may be formed. Yet this will seldom lead to the formation of callus. If a mass seems to form between the ends of the fracture, it is usually destroyed just as rapidly. As a rule then the destruction of callus formation is immediately resumed, but not always. At times a true union seems to take place and may exist for considerable time. Bruns cites 4 cases where beginning union was shown by section.

Grunert found three other examples; one, a case reported by Vernuil, which occurred in a patient whose fracture was through the left lower leg and in which union took place after the pathological fracture and existed for over a year; the other 2 cases, reported by Desprès, were cited by Picqué. The first was a fracture of the femur associated with sarcoma; the fracture united and the patient lived for a year. The second was a fracture following very slight trauma involving a very aggressive tumor. Notwithstanding, union took place one month later and one month thereafter a second fracture, followed by consolidation, occurred.

The following observations of Grunert are of sufficient importance, despite the fact that they were made twenty-five years ago, to warrant quoting in full.

While we must proceed at once to an amputation of the extremity in cases of pathological fractures due to sarcoma, it would be a mistake in cases of carcinoma, since the patient is already doomed to die, and it would force him to undergo the loss of a limb in his last days. We are justified in saying that in carcinoma, that is to say, true carcinomatous metastasis,

\* From the Department of Bone Sarcoma, Memorial Hospital, Service of Dr. William B. Coley.  
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union of the fragments can never occur. Up to this time there has never been a reported case of such a recovery. Isolated examples of bone fragility in carcinoma really belong to our group No. 2, where the fragility does not follow the local disease, but is a constitutional diathesis—a generalized bone atrophy. One finds, therefore, no traces of carcinomatous cells at the site of fracture. In rare cases it is possible perhaps that a fracture may unite. This is how I account for the case of von Richet (cited by Picqué) which was that of a woman who broke her lower leg as she was about to step into a carriage. No trace of tumor could be found. A short time later the patient showed Richet a small ulcerating cancer of the breast. In the meantime the fracture had been uniting slowly for two months. The etiology of the fracture was clear. It was doubtless an example of breast cancer; yet the course of the fracture proves that it was not due to a local pathology in the bone structure, but concerns itself with a constitutional tendency. Von Bruns gives three other cases which were confirmed by pathological sections.

Codman, in 1921, in a brief summary of the subject deals in particular with fractures occurring in primary bone sarcomata. His article, though brief, is replete with useful information and is based on his early experience as Registrar of the Special Committee on Bone Sarcoma of the American College of Surgeons. Aside from these authors, most of the recent literature consists of isolated case reports which do not permit of general conclusions. Among these may be mentioned Gessner, Noon and Karp. Gessner lists 2 cases of fracture following an especially violent injury. In both cases immediate x-rays showed fracture and in neither case was there any suspicion of malignancy until after the lapse of some weeks. It was only when symptoms of pain in one case and swelling in the other became prominent that subsequent x-rays were taken. These showed unmistakable evidence of malignancy at the site of fracture. This brings up the question of whether these cases represent fracture followed by the development of sarcoma or preexisting sarcoma with pathological fracture. A second study of the

original x-ray films in each case was made and the roentgenologist reported that there was osteoporosis and thinning of the cortex sufficient to justify the opinion that disease existed at the time of fracture in both cases, although admitting that no tumor appears in the early pictures. No comment whatever as to the existence of bone pathology other than fracture was reported in the original x-ray diagnoses. The violence in 1 case consisted of a fall from a horse resulting in a comminuted fracture of the femur; and in the other case the patient was struck on the arm by a street car and sustained a fracture of the humerus. In conclusion, Gessner believes that the x-ray evidence should be paramount and that both of these cases represent pathological fracture through diseased bone rather than fracture through healthy bone followed by the development of sarcoma. The former view undoubtedly is more in keeping with current opinion, but there are unquestioned examples of the development of sarcoma following fracture through perfectly normal bone.

William B. Coley has observed 6 cases in which the sarcoma developed at the site of a recent fracture. In each instance x-rays taken immediately after the fracture showed no evidence of a pathological condition of the bone and yet the sarcoma developed at a varying interval thereafter. In his opinion, these cases are proof that the sarcoma developed after the fracture.

Bloodgood has reported 3 cases which he regards as rare examples of the formation of a sarcoma at the site of a fracture, and Codman has a similar case.

The ratio of pathological fractures to all fractures has been obtained by Rassieur, who studied the records of a St. Louis hospital and found 588 fractures with 5 pathological fractures, or almost 1 per cent. Of these 5 cases, one was due to chronic osteomyelitis; one to bone syphilis; one to infiltrating epidermoid carcinoma of the leg; one to metastatic carcinoma of the breast and one to primary osteosarcoma. Thus but one pathological fracture

due to a primary bone tumor was found in 588 fractures, or .17 per cent. According to Bloodgood, pathological fracture occurs in 12 per cent of benign and malignant bone tumors considered together. In his records there were 9 fractures in 144 cases of giant-cell tumors and 25 fractures in 287 cases of primary bone sarcoma. He gives the percentage of pathological fracture in myeloma as 25.

This study is based on a series of 185 cases of primary bone tumors of the extremities of which 42 were complicated by pathological fractures. The cases were collected from the Bone Sarcoma Department of Memorial Hospital over a ten-year period (1919-1928).

We have not considered metastatic bone tumors in this study. Furthermore, we have limited ourselves to pathological fractures due to primary bone tumors in the long bones of the extremities, because they occur more frequently and are of more importance in the treatment and prognosis than those arising in other portions of the skeleton. Emphasis is placed on the effect that pathological fractures have on the duration of life and on the care of the patient after the occurrence of the fracture.

The diagnosis is based on the clinical, x-ray and histological findings in 114 cases; in the remaining 71, it rests on clinical and x-ray findings, which appear to us to be conclusive. It has been shown by Putti and others that clinical history, careful examination and x-ray studies are sufficient in the majority of cases to form an accurate diagnosis in primary tumors of the long bones. Cases have been excluded in which the records are practically deficient or lacking in essential data. Otherwise they represent unselected cases.

Osteogenic sarcoma was not separated into sub-types. It is the most frequent with 65 per cent of the total number of cases. It should be remembered, however, that prior to 1924 Ewing's tumor (endothelial myeloma) was not diagnosed as such and undoubtedly a few cases of this

type may be included in the osteogenic group.

Giant-cell tumor is next in frequency, with 19 per cent, and endothelial myeloma least with 14 per cent, as shown in Table 1.

TABLE I

	Total No.	Percentage Frequency, Per Cent	Total No.* of Fractures	Percentage of Fractures, Per Cent
Osteogenic sarcoma.....	122	65.9	26	21.3
Giant-cell tumor.....	36	19.5	9	25
Endothelial myeloma.....	27	14.6	7	25.7
Total.....	185		42	22.7

\* Eight cases in small bones of hands and feet are not considered.

There are 42 fractures in the 185 cases of all types, or 22.7 per cent. The incidence of fracture is strikingly uniform in the three types of tumor. Endothelial myeloma shows a slightly greater tendency to fracture but not as great as might be expected from a consideration of its pathology, for it is characterized by bone destruction, often widespread, and by little, if any, new bone production. Fractures in giant-cell tumors are next in frequency. Here again we are dealing with a central tumor, chiefly osteolytic. Osteogenic sarcoma has a fracture incidence of 21.3 per cent with 26 fractures in 122 cases. As might be anticipated, the majority of fractures occurred in the medullary tumors, most of which were of the telangiectatic variety.

Figures were supplied us from the Bone Sarcoma Registry through the courtesy of Dr. Bowman C. Crowell, registrar, which showed a similar relative frequency of fracture in the three types of tumor, but the ratio in all of the fracture cases to total tumor cases is much lower. The figures of the Registry are as follows: osteogenic sarcoma, fracture in 7.73 per cent; giant-cell tumor, fracture in 6.36 per cent, and endothelial myeloma, fracture in 4.26 per cent. The marked difference in the Registry cases and in our own series is difficult to explain. It may be that surgeons have often



neglected to inform the Registry of the development of a fracture in cases they have previously reported. Moreover, their series comprises sarcoma of all bones, whereas ours is confined to long bones and it is well established that the latter are far more prone to undergo pathological fracture. Another reasonable explanation of the higher percentage of pathological fracture in our series lies in the fact that in the Registry cases and those in Bloodgood's records amputation probably occurred earlier than in ours, where x-ray and radium were given an extended trial.

#### CLASSIFICATION OF PATHOLOGICAL FRACTURES

- I. Fractures due to Primary Tumors of Bone
  - A. Benign.
    1. Osteitis fibrosa cystica (bone cysts, fibrocystic diseases of bone)
    2. Osteitis deformans (Paget's disease)
    3. Benign giant-cell tumor
    4. Enchondroma, myxoma, etc.
  - B. Malignant.
    1. Osteogenic sarcoma
      - a. periosteal
      - b. sub-periosteal and medullary
      - c. telangiectatic
      - d. sclerosing
      - e. fibrosarcoma
      - f. atypical—unclassified
    2. Myeloma
      - a. endothelial myeloma
      - b. plasma cell myeloma
      - c. myelocytic
      - d. lymphocytic
      - e. erythroblastic
    3. Liposarcoma
- II. Fractures due to Metastatic Tumors.
  - A. Osteogenic sarcoma (primary in another bone).
  - B. Endothelial myeloma.
  - C. Carcinoma
 

$\left\{ \begin{array}{l} \text{prostate} \\ \text{thyroid} \\ \text{kidney} \\ \text{breast, etc.} \end{array} \right.$

#### III. Fractures due to Inflammatory Processes.

- A. Pyogenic osteomyelitis (suppurative (non-suppurative)
- B. Tuberculosis of bone.
- C. Syphilis of bone.
- D. Echinococcus disease of bone.

#### IV. Fractures due to Constitutional Bone Changes.

- A. Old age.
- B. Atrophy of disuse.
- C. Chronic wasting diseases.
- D. Rickets and osteomalacia.
- E. Scurvy.

#### V. Miscellaneous.

- A. Aneurysm.
- B. Brodie's abscess.
- C. Idiopathic bone fragility.

Age: The age incidence in the series we have studied conforms closely to the figures reported by other observers. (See Table II.) The average age of osteogenic

TABLE II  
AGE INCIDENCE

	Without Fracture (Years)	With Fracture (Years)
Osteogenic sarcoma.....	23.7	37.1
Giant-cell tumor.....	33.0	31.3
Endothelial myeloma.....	18.7	38.2

sarcoma without pathological fracture was 23.7 years; with fracture it was 37.1 years. Giant-cell tumors averaged 33.0 years in cases without and 31.3 years in cases with pathological fracture. In the endothelial myeloma group the average age of cases without fracture was 18.7 years, while with fracture it was 38.2 years. Christensen, in a classification of 1000 cases of bone tumors found that the incidence of osteogenic sarcoma reaches its height at fifteen years and declines rapidly thereafter; while giant-cell tumors are most common in the third decade of life. Endothelial myeloma, he found most common in early life, more than half occurring before the age of twenty.

In attempting to explain the later onset of the osteogenic and endothelial myeloma cases which were associated with patho-

similar that it seems to have no influence; this may be due to the fact that there is much less variation in the period of onset,

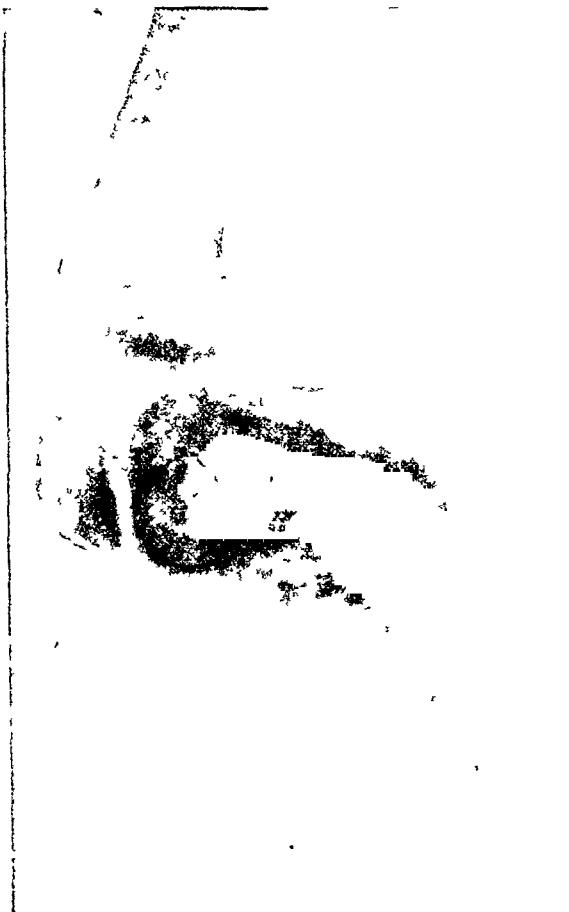


FIG. 1. Osteogenic sarcoma with pathological fracture lower end of femur; woman of 33; radium and x-ray therapy; amputation, 1924; alive and well March, 1928.



FIG. 2. Telangiectatic osteogenic sarcoma with pathological fracture shaft of humerus boy of twelve; x-ray therapy; amputation, December, 1922; alive and well six years and six months.

logical fracture, we raise the question whether the reaction of the bone to the invading tumor may not be different in the younger subjects, just as bone repair after fracture is far more rapid, and often more extensive, in young, than in older individuals. Or may it be due to a predilection of the central type of subperiosteal and medullary, or telangiectatic osteogenic tumors for patients past the average age for the whole group. This latter hypothesis, however, fails to account for the higher age incidence in the endothelial myeloma cases with fracture.

The age incidence of giant-cell tumor, both with and without fracture, is so

it being far more frequent in the third and fourth decades.

**Sex:** As has been pointed out by others, osteogenic sarcoma is more frequent in males than in females; in this series there were 74 males and 47 females; giant-cell tumors affect the sexes about equally, there being 19 females and 15 males; endothelial myeloma is much more frequent in the male sex, there being 21 in males and 6 in females, which corresponds roughly to Christensen's findings in a larger series.

We find little to suggest that sex plays a part in the development of a pathological fracture in cases of osteogenic sarcoma or endothelial myeloma. On the other hand,

out of 9 pathological fractures in the giant-cell tumor group, 8 occurred in women, a fact we are unable to explain.

occurring in 28.1 per cent of the cases, as opposed to 18 per cent in the lower extremity. It would seem, therefore, that

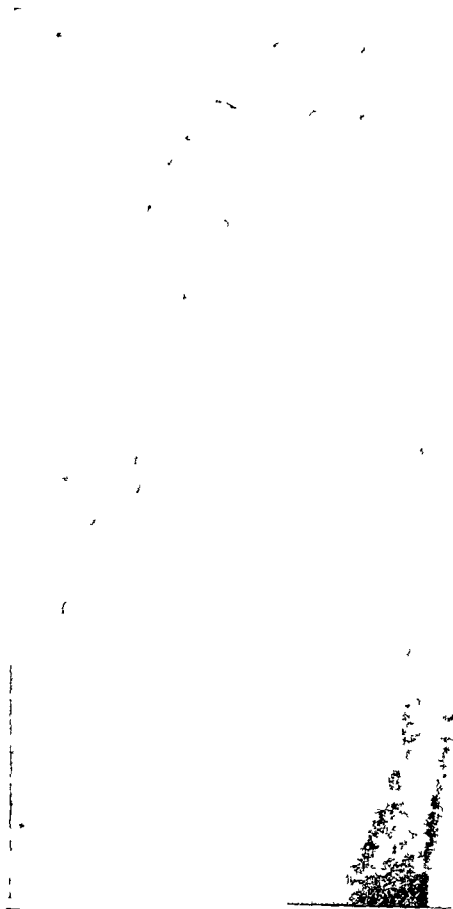


FIG. 3. Telangiectatic osteogenic sarcoma of femur with pathological fracture in a girl of six years. Amputation—death from pulmonary metastasis.



FIG. 4. Endothelioma of shaft of femur with pathological fracture man of 20; x-ray therapy; toxins, amputation; death from pulmonary metastasis.

**Location of Tumor:** Considering the three types of tumor separately, we found that the location followed closely the sites of predilection that have become well known as a result of the studies of earlier observers. Table III shows in detail the total number of cases of each of the types of tumor occurring in each bone and in the portion of the bone; in addition, the small numbers represent the number of cases with pathological fracture.

Three-fourths of the primary bone tumors in this series are found in the bones of the lower extremity. Fracture is relatively much more common as a complication of tumors of the upper extremity,

weight-bearing does not play an important rôle in the occurrence of fracture. The high proportion of all tumors of the upper extremity that are situated in the proximal

TABLE III  
LOCATION OF TUMOR AND FRACTURE

	Femur	Tibia	Fibula	Humerus	Radius	Ulna
	P S D	P S D	P S D	P S D	P S D	P S D
Osteogenic sarcoma..	18 6 39 7 8	21 4 3	4 2 1	20 1 4 6	2 2	
Giant-cell .....	2 10 2 2	12 1	3	3 1 2 3	3 1	
Endothelial myeloma	4 5 2 1 1	2 2	3 1	4 2 3 1	2	1

Note: Large numbers, total tumor cases. Small numbers, cases with fracture. P, Proximal end; S, shaft; D, distal end

end of the humerus (30 out of 45) may be an important reason for this high incidence; especially since 12 of the 16 pathological fractures of the upper extremity occurred in tumors of the proximal end of the humerus. It would appear from a study of the mechanics of the upper extremity that this point is subjected to greater stress than any other. We were struck by this high rate of fracture in the upper part of the humerus and submitted our theory to Codman, who was kind enough to write as follows.

When you consider that the arm is a lever which has its fulcrum at the shoulder joint and that the power to abduct is applied on a relatively very short lever, namely from the attachment of the supraspinatus to the glenoid and from the deltoid attachment to the glenoid, you see what a great stress is put on the humerus in this region. Yet we lift our arms unconscious of their weight, although they may weigh five to ten pounds. When a small object is held in the hand, which is at the end of the long lever, the stress at the attachment of the deltoid and supraspinatus must be greatly increased. The humerus does not develop an extremely thick cortex like that of the femur because the arm is little used in weight bearing. Tumors of the humerus are particularly common at the deltoid tubercle and in the spongy bone beneath the supraspinatus attachment and it is no wonder that fracture occurs at this point.

*Interval between Onset of Symptoms and Fracture:* The initial symptom was referable to fracture in approximately one-fifth of all the cases (9 out of 42, or 21.4 per cent). (See Table iv.) Symptoms preceded the fracture in all the endothelial myeloma

group. Pathological fracture initiated the first symptoms in 5 of the 9 cases of giant-cell tumor. In the five with simultaneous onset of symptoms and fracture, two occurred while walking and one while doing down stairs resulting in sudden collapse and pain; the fourth followed a fall on the ice and the fifth was caused by a blow from a crank handle. Three of these were spontaneous and two followed trauma. Tumor was definitely demonstrated by examination and x-ray immediately following the fracture in these cases.

In the osteogenic sarcomas, 4 of the 26 patients dated their trouble from the time of fracture. One boy was throwing a ball; another was skating and suddenly collapsed; a third fell from a ladder, sustaining a fracture; and the fourth fell and also sustained a fracture. Two were spontaneous pathological fractures and 2 followed trauma. The 2 spontaneous fractures were in rapidly growing tumors and the pathology showed that 1 was of the periosteal type and the other medullary. Histological material was not obtained in the 2 traumatic cases.

Where fracture occurred after the beginning of symptoms, the average interval between first symptoms and fracture was about one year in the osteogenic sarcoma, four months in the giant-cell tumor and eight months in the endothelial myeloma group.

*Symptoms of Pathological Fracture:* The symptomatology in this group coincides with the typical textbook descriptions. As shown here, an average of one year elapsed before fracture in the osteogenic group. This is a very rough estimate, as one fibrosarcoma was present five years before fracture. The different types, therefore, vary greatly in their interval period between onset of symptoms and fracture. These estimates for giant-cell tumor and endothelial myeloma represent a truer sequence of events.

*Types of Fracture:* Fractures may be either complete or incomplete. In the

TABLE IV  
FRACTURE AS INITIAL SYMPTOM

	Fracture with Onset of Symptoms No. of Cases	Fracture Following Onset of Symptoms	
		No. Cases	Average Months
Osteogenic sarcoma.....	4	22	12.2
Giant-cell.....	5	4	3.8
Endothelial myeloma.....	0	7	7.8

early stages they are often incomplete and are picked up solely from a study of the x-ray films; many of these become com-

without displacement; but displacement is greatly hampered by the presence of the tumor tissue about the site of fracture, so that marked over-riding is unusual. Except in the case of fractures occurring in giant-cell tumor and benign cyst (osteitis fibrosa cystica), there is seldom much shortening for the same reason. Certain of the medullary tumors may fracture subperiosteally with, however, later tearing of, or invasion of the periosteum as the destruction of bone goes on apace and the mechanical factors responsible for the fracture continue to operate. Pulsation of the tumor at the site of fracture has been observed. It is sometimes seen in the malignant bone aneurysm (telangiectatic osteogenic sarcoma), angioendothelioma and vascular metastatic tumors of the thyroid.

*Differential Diagnosis:* It is undoubtedly difficult to make a correct diagnosis of the underlying cause of a pathological fracture in a certain percentage of cases. This difficulty, inherent in the diagnosis of bone tumors and associated conditions, is enhanced by the alteration in the x-ray picture which is produced by the fracture. The age of the patient, the location of the tumor, the presence or absence of symptoms (and their duration) prior to the fracture, are important and should be considered in conjunction with the x-ray films. The latter should include not only several views of the site of fracture but also the lungs and other bones of the skeleton.

It is a point worthy of mention that late films after much bone destruction has taken place and where a pathological fracture has further altered the typical appearance would make it very difficult to distinguish between a giant-cell tumor and a malignant bone aneurysm (telangiectatic osteogenic sarcoma). Previous operation may so alter the x-ray appearance as to lead to diagnostic difficulties.

The physical examination should include a careful investigation of the possible sources of carcinoma which is prone to

FIG. 5. Angioendothelioma of tibia and fibula with pathological fracture; man of 28; x-ray; toxins; amputation, June, 1926; pulmonary metastases present at time of amputation; alive and working; symptom free June, 1929—three years and six months after amputation.

plete as further bone destruction takes place. They may occur as compression fractures, due to the buckling caused by weight-bearing. This type is not unusual in giant-cell tumor of the upper extremity of the tibia or lower extremity of the femur. They commonly occur as "rotten-wood" fractures due to progressive involvement of the entire thickness of the bone. These are often seen in endothelial myeloma and in the medullary, or subperiosteal and medullary osteogenic sarcoma of the shaft of the bone. Fractures may be with or

metastasize to bone (kidney, breast, thyroid, prostate, etc.).

Within the past year 4 cases of un-

radiological diagnosis of osteitis fibrosa cystica was made. The Wasserman test was also positive. Firm union occurred

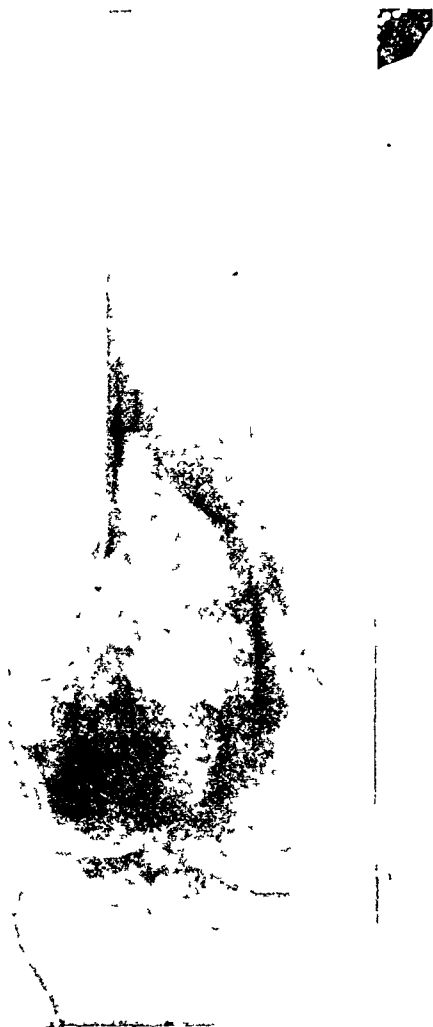


FIG. 6. Giant cell tumor with compression fracture of distal end of femur; woman 37. Curettage; radiation; amputation; alive at present—2½ years later.



FIG. 7. Atypical giant cell tumor, prolonged x-ray therapy; pathological fracture with limb in position of marked flexion deformity; amputation October, 1927; free from disease at present.

suspected hypernephroma with bone metastasis have been referred to the Bone Department of Memorial Hospital. This type of metastatic bone carcinoma may closely simulate the angioendothelioma primary in bone; and even the histological diagnosis between these two conditions is difficult.

Bone syphilis is sometimes associated with a pathological fracture. Gratz has recently reported a case in which the

within seven weeks under x-ray and antiluetic treatment.

A boy of thirteen was seen with a pathological fracture of the neck of the femur due to osteitis fibrosa cystica; he was referred from another hospital as a case of sarcoma. Another case was seen with a similar lesion in the same location, and a third case in which the humerus was the seat of three successive pathological fractures, each of which was promptly followed

by union. This condition is sufficiently frequent to warrant its being considered in pathological fracture in adolescents.

As to the question of distinguishing between the three principle primary bone tumors, it may be said that mistakes will occur even where the closest attention is paid to the history, clinical findings and x-ray features, though these constitute a minority of all cases. The importance of the evidence obtained by a careful study of adequate x-ray films cannot be over-emphasized.

*Treatment of Pathological Fractures:* In considering the treatment, both the bone tumor and the complicating fracture require attention. The variety of tumor influences the treatment, since it is essentially different.

*Prevention of Pathological Fractures:* Since pathological fracture so greatly contributes to the distress of the sufferer and to the difficulties in managing the treatment of the case, great care should be taken to avoid it, or postpone it as far as possible. It seems quite illogical to treat cases of malignant bone tumors, especially of the lower extremity, as ambulatory. Prolonged immobilization in cases that are being treated with x-ray and radium is an important part of the treatment. In many instances, owing to lack of bed space, this has not been possible. In giant-cell tumors, the prognosis for saving a limb with useful function after pathological fracture has been in our experience quite favorable. In this type of tumor, however, the aim should be to institute treatment early and protect against any trauma that might result in a fracture.

*Treatment of Osteogenic Sarcoma with Pathological Fracture:* Immediate amputation well above the site of fracture is the method of choice, provided no clinical or x-ray evidence of pulmonary metastasis exists. This is followed by injections of the mixed toxins, both intramuscular and intravenous, as a prophylaxis against recurrence. It may be shown subsequently

that postoperative prophylactic radiation of the pulmonary fields with high voltage deep x-ray therapy is worth while. This is now being given a trial in some cases. There is little to hope for in this type of tumor from the standpoint of postoperative radiation, owing to the lack of radiosensitivity of osteogenic sarcoma and the depth of the pulmonary fields. Preliminary radiation prior to amputation in cases with fracture has not yielded results sufficient to warrant delay in amputation. If metastases have already occurred, amputation may still be justified to relieve the patient of a painful condition which does not lend itself to conservative treatment. Plaster splints, casts and traction suspension methods all have their individual indications.

*Treatment of Endothelial Myeloma with Pathological Fracture:* Here two factors present therapeutic indications quite different from the osteogenic group. The first is the now well-established fact that this tumor is particularly radiosensitive. The second is the frequency of multiple bone and lung metastases, occurring early, which makes amputation discouraging even from the standpoint of temporary palliation. It is therefore advisable to immobilize the fragments in as satisfactory apposition as possible, while radiation, preferably by combined radium pack and high voltage x-ray cycles, is pushed to the limit of skin tolerance. It is a clinical conviction that this tumor is also responsive to toxin treatment and this should be administered vigorously at the same time. If sufficient regression occurs and widespread metastases do not supervene a later amputation may be advisable when it becomes evident that non-union and a useless extremity will be the end-result. We have not used interstitial radiation in endothelial myeloma cases. The results of this form of radiation have not been encouraging in the few cases of osteogenic sarcoma in which it has been tried. External radiation is undoubtedly preferable.

*Treatment of Giant-cell Tumors with Pathological Fracture:* Here one encounters conflicting opinions and it is admittedly the group that offers the greatest difficulty in the establishment of a standardized method of treatment. In fact, each case must be considered individually and a decision reached as to the best course to pursue after all factors are weighed. In the first place, there is a considerable variation in the aggressiveness of even the benign type of giant-cell tumors of long bone, although we recognize that the majority are only locally invasive. A small but important fraction, however, will eventually metastasize to the lungs, and it is not always possible to distinguish them by clinical and x-ray study from those which run a benign course. Ewing believes that they can be distinguished histologically and that the typical benign giant-cell tumor never metastasizes unless it has been subjected to the trauma of an operation.

Furthermore we find occasional cases in which the clinician and the roentgenologist agree on a diagnosis of benign giant-cell tumor, but where the response to treatment fails to justify this diagnosis and later an amputation is performed and an osteogenic central tumor found.

Herendeen has demonstrated that benign giant-cell tumors may be successfully treated with x-ray. In some instances, control of the growth by the laying down of new bone in the tumor has been accomplished by comparatively small doses of this agent. In our early work, having no standard dosage to guide us, there is no doubt that some of these cases were over-treated. A certain proportion appeared to be favorably influenced and later developed signs of a renewed activity, requiring further radiation. A few have failed to respond from the start and have been amputated. It is reasonable to expect, however, that in the future amputation will seldom be necessary in the management of a case of benign giant-cell tumor. Giant-cell tumor complicated

by fracture (and this does occur in about one-fourth of all cases) should be treated by immobilization in the best anatomical



FIG. 8. Osteitis fibrosa cystica of upper extremity of femur; pathological fracture; union with deformity subsequently corrected by osteotomy.

alignment of the fragments that is obtainable, during the period when exposure to x-ray treatment is taking place. In a large proportion of these cases a pathological fracture will unite under treatment. Even after union has begun to take place prolonged protection by splints (ambulatory Thomas, etc.) is advisable.

A convenient method of immobilization is afforded by the use of circular plaster casts which have been bivalved, permitting removal for exposure to x-ray or radium and immediate replacement until such time as another treatment is indicated.

After sufficient time has elapsed to permit deductions as to the response of the individual tumor to x-ray, a decision can



be reached as to whether further trial with this form of treatment is indicated or whether some form of surgery is necessary. Curettage followed by carbolic acid or zinc chloride application has been used successfully by Bloodgood and has yielded satisfactory results in a number of instances in our hands. This method, however, has been followed by infection, failure to heal and, in some instances, fungation of the tumor tissue, and we have ample evidence that it is a procedure not without risk in the hands of the general surgeon. We believe it is never indicated in cases associated with pathological fracture. We have not been impressed with the more extensive operative procedure such as bone graft, muscle and fat transplantation and the use of bone chips in the cavity.

*Prognosis:* It is difficult to estimate the influence of a pathological fracture on the prognosis of a primary bone tumor of the extremities. It is demonstrable from a study of this series that the duration of life of the osteogenic group is definitely shortened. Whether this is due to the fact that in those cases in which fracture occurs there is a more rapid rate of tumor growth or whether by virtue of the fracture greater opportunity is afforded for early dissemination of the disease cannot be stated definitely. As shown in Table v in the cases with fracture, death occurred on an average of ten months earlier than in the cases in which there was no pathological fracture.

The endothelial myeloma group is composed of too small a number of cases of fracture to make trustworthy deductions as to the influence of fracture on the duration of life.

In the giant-cell group there was no mortality in cases with fracture. The period of active treatment, however, was considerably prolonged and the end-result definitely less favorable in those associated with pathological fracture.

*Union after Pathological Fracture:* There is some difference of opinion as to the frequency with which pathological fracture due to primary bone tumor unites. Blood-

TABLE V  
DURATION OF LIFE IN PATIENTS WITH OSTEOGENIC SARCOMA

	Onset to Death Average Months	Not Traced (Cases)	Still under Observation (Cases)
Non-fracture cases.	23 (59 cases)	15	13
Fracture cases.....	13.8 (14 cases)	4	8

Giant-cell cases, all alive.

E. M. cases, series too small to base accurate conclusions as to influence of fracture on duration of life.

good states that healing of a pathological fracture in primary bone sarcoma occurred twice in 25 fractures. William B. Coley reports 2 cases of endothelial myeloma of the humerus in which under toxin and radium treatment the pathological fracture healed. One of the patients is well five years later with full restoration of function; and in the other, a more recent case, the fracture united in four weeks under the same form of treatment and the patient is well six months later.

In the giant-cell tumor cases with pathological fracture 7 of the 9 achieved union. Four of these were located in the femur. They were all followed for periods ranging from five to eight years and were free from disease. Of the two remaining, one was traced only one month and the other was amputated for a recurrence following curettage and x-ray therapy.

Of the 7 cases of endothelial myeloma with fracture, firm union was obtained in 3. Two were amputated and non-union persisted until death in 1 case and in the remaining case there were no later notes about the condition of the fracture. Excluding this latter case and the 2 that were amputated, it would appear that in 3 of the 4 remaining cases union occurred.

*Conclusions:* 1. Pathological fracture occurred as a complication in 22.7 per cent of a series of 185 primary bone tumors of the extremities. Divided into types, fracture occurred in endothelial myeloma in 25.7 per cent; in giant-cell tumor in

25 per cent and in osteogenic sarcoma in 21.3 per cent.

2. Pathological fractures are most likely to occur in patients past the average age for the corresponding tumor.

3. Three-fourths of the tumors occurred in the lower extremities.

4. Pathological fractures are most common in the upper extremity and the upper end of the humerus was the region of greatest susceptibility to fracture (12 out of 16 cases), an explanation for which is offered.

5. In this series of 42 fractures, tumor preceded fracture in every instance.

6. Fracture was the initial symptom in one-fifth of all cases; it did not occur as an initial symptom in any of the endothelial myeloma cases.

7. The life expectancy of a patient with osteogenic sarcoma in whom pathological

fracture has occurred is shortened 60 per cent.

8. All the patients with fracture in giant-cell tumor are living one to eight years.

9. Fracture increases the difficulty in handling cases with primary bone tumors, especially ambulatory treatment with x-ray and radium.

10. Fracture was followed by union in 3 of the 7 cases of endothelial myeloma; in 7 of the 9 cases of giant-cell tumor; and in none of the 26 cases of osteogenic sarcoma.

11. Pathological fracture may be postponed or even prevented entirely by early and continuous support.

12. The failure to immobilize a limb in which a pathological fracture has already occurred may predispose to early dissemination.

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# DIAGNOSTIC NOVOCAINE BLOCK OF THE SENSORY AND SYMPATHETIC NERVES

A METHOD OF ESTIMATING THE RESULTS WHICH CAN BE OBTAINED BY THEIR PERMANENT INTERRUPTION\*

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DURING the past year a method has been developed on the Surgical Services of the Massachusetts General Hospital to determine the benefit of proposed operations for pain and circulatory disease. This test shows the surgeon who is planning an interruption of the cerebrospinal nerves or the resection of sympathetic ganglia just what the contemplated operation can accomplish in the way of relief of obscure pain or increasing peripheral circulation. This can be accomplished by the use of regional anesthesia, which has now reached such a perfection of technic that almost any important nerve in the body can be selectively blocked.

The pioneer in the use of novocaine for determining the pathways of obscure pain was Von Gaza.<sup>1</sup> His work has received little recognition in this country, but it is being carried on and amplified by Leriche in Strasbourg<sup>2</sup> and by Archibald<sup>3</sup> and Scrimger<sup>4</sup> in Montreal. The purpose of this paper is to point out the great value of the preliminary injection of novocaine in localizing the cerebrospinal or sympathetic trunks which are carrying painful stimuli. A second very useful application of this method has been recently developed in the Circulatory Clinic at the Massachusetts General Hospital,<sup>5</sup> a test to estimate quantitatively the increase in peripheral circulation which will follow sympathectomy.

The technic of injecting the main nerve trunks to the extremities, the spinal nerves, and the sympathetic rami and ganglia is beyond the scope of this paper. It has been very well described by Labat.<sup>6</sup>

I have used this procedure diagnostically in a series of 29 cases with only a single misleading result. (Table 1.)

## I. DIAGNOSTIC NOVOCAINE BLOCK TO DETERMINE THE PATHWAYS OF VISCERAL PAIN

Ranson<sup>7</sup> has shown histologically that sensory fibers run in the sympathetic nerves and enter the spinal cord through the white rami of the dorsal and upper lumbar region. Whether these are true sympathetic or cerebrospinal fibers is as yet undetermined; but it is a point of purely academic interest, because there is now not the slightest question that interruption of the white rami can relieve pain of visceral origin. That sensory fibers from the heart, aortic arch and lungs run to the cord through the upper five to six thoracic rami has been proved through paravertebral injection by Mandl,<sup>8</sup> Swetlow,<sup>9</sup> Mixer and White.<sup>10</sup> Laewen<sup>11</sup> has shown by infiltrating novocaine around the lower thoracic and upper lumbar white rami in patients suffering from severe abdominal pain, that the sensory fibers of the upper abdominal viscera run in the splanchnic nerves and enter the cord in the following segments.

Esophagus.....	D <sub>5</sub> -D <sub>6</sub>
Stomach.....	D <sub>7</sub> -D <sub>8</sub>
Gall bladder....	D <sub>10</sub> (right)
Small intestine..	D <sub>9</sub> -D <sub>10</sub>
Kidneys.....	D <sub>12</sub> -L <sub>1</sub>
Appendix.....	L <sub>1</sub> -L <sub>2</sub> (right)

The large majority of patients suffering from visceral pain are of course relieved by proper treatment of the diseased organs. Nevertheless, there are frequent

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TABLE IA  
NOVOCAINE BLOCK TO TEST EFFECT ON THORACIC AND ABDOMINAL PAIN

Case	Disease	Injection	Result	Temperature	Operation	Success
I	Painful metastatic cancer of sternum.	Intercostals 2-4 (right)	Shown number of intercostal nerves to be cut.	+ 3° 0	Cutting intercostals 2 to 4	Yes
II	Tabes with crises.	Thoracic D4-D7 Gastric D7-D11 D10	Stopped thoracic crises for a day. Stopped gastric crises for 36 hrs.		Ramisetomy D1-D7. Resection splanchnic nerve D7-D10 ganglia.	Yes
III	Severe right upper quadrant pain with congenital lesion 10th dorsal vertebra.		Pain disappeared for 4 hours.		Alcohol injection D1	Yes
IV	Aneurysm ascending aorta.	D1 and D2 (right)	Stopped pain for 36 hours.		Alcohol injection D1-D2	Yes
V	Angina pectoris.	D1 and D2 (left)	Excision of these ganglia should stop attacks.		Resection of stellate and D2	Yes
VI	Carcinoma lung and pleura.	D1 and D4	Stopped pain for several hours.		Alcohol injection D1-D2	Yes
VII	Right upper quadrant pain after multiple operations. Cause unknown.	D12	Pain disappeared for 3 hours.		Resection of D12 ramus.	Yes

instances when the disease itself is incurable, where the patient can be made tolerably comfortable by interrupting the pain. In other cases the suspected organs, most often the gall bladder or the appendix, have been removed but the pain has continued. In still other conditions, the painful focus apparently lies in the central nervous system, but denervation of the areas to which the pain is referred can cause it to disappear. In such obscure problems, preliminary injection of novocaine can throw much light upon the mechanism of pain and a subsequent operation can be undertaken with a definite assurance of success. It is in these baffling instances that Von Gaza's method is most useful.

#### CASE HISTORIES

The entire series of 29 cases is summarized in the tables, but only those of particular interest will be discussed in greater detail.

CASE II. A Jewish tailor who complained of extremely painful tabetic crises of four years' duration in his left chest and abdomen, as well as in both legs. All forms of antileptic therapy had been tried without result. Section of his seventh to eleventh dorsal posterior roots had produced abdominal anesthesia to pin-prick, but had not diminished skin hyperesthesia to touch or cold, nor had it had any effect on his gastric crises. Two cordotomies, in spite of

causing considerable bladder disturbance, had only produced numbness of the left leg. Paravertebral injection of novocaine from D7 to D11 gave absolute relief of his abdominal pain for thirty-six hours, as well as producing a complete numbness of the skin. With this lead, Dr. W. J. Mixter resected the left splanchnic nerve with the eighth to tenth thoracic ganglia. This operation has given relief of his abdominal crises to date (six months). I have since done a similar test injection of his fourth to seventh segments to see if it would relieve the thoracic crises. As it was again successful, I have cut the corresponding rami with similarly good results.

It is interesting to note that an injection of his lumbar sympathetic trunk had no effect on the painful crises in his right leg. In another tabetic patient, injection of the posterior tibial nerve temporarily relieved a severe crisis in the sole of his foot.

Leriche<sup>12</sup> and Van Bogaert and Verbrugge<sup>13</sup> also have used this method and have concluded that sympathetic ramisection is a far better operation for gastric crises than section of the posterior roots.

CASE III. A woman of forty-five, after the sudden death of her husband, developed attacks of severe lancinating pain from her right costal margin to the umbilicus. After prolonged observation, nothing abnormal had been found except a peculiar lesion of her tenth dorsal intervertebral disk. This had been declared to be a congenital abnormality by two

x-ray consultants. She was then explored and a slightly abnormal looking gall bladder removed. As a result, her previous pain

blocking his first and second dorsal sympathetic rami on the right side. Alcohol injected into the same areas relieved the pain entirely until



FIG. 1a.

FIG. 1b.

FIG. 1. CASE IV with aneurysm of ascending arch of aorta. To show widespread distribution of pain and points of injection of first and second dorsal sympathetic rami.

became so severe that it was not controlled by 3 grains of morphine daily. Diagnostic novocaine injection of her ninth, tenth, and eleventh spinal nerves and sympathetic rami caused the pain to disappear entirely. A paravertebral alcohol injection of the tenth nerve was then performed and the pain disappeared for three months. The pain has now recurred in a milder form, so that the nerve will probably have to be cut to give her permanent relief.

In this nervously exhausted patient who had already been put through a major operation without relief, the novocaine test gave us an assurance that a relatively simple alcohol injection could alleviate her suffering.

CASE IV. A very thick-set railroad employee of forty-nine entered the hospital with a huge aneurysm of the ascending arch of his aorta, which was bulging out between his clavicle and first rib. There was marked venous engorgement of his head and severe constant pain over the entire area shown in Figure 1. When he coughed the pain was intolerably severe. By means of paravertebral novocaine block it was demonstrated that the pain referred over this wide region could be stopped completely by

he died three months later of rupture of the aneurysm.

As this pain was referred over a large portion of his cervical and upper dorsal



FIG. 2. CASE V. Area of referred pain in angina pectoris, relieved by novocaine infiltration and excision of first and second dorsal ganglia.

segments, we would have been quite in the dark as to which segments to attack without the knowledge secured by the preliminary injection of novocaine.

CASE V. A young man of twenty with rheumatic heart disease and aortic regurgitation was having up to 18 severe attacks of angina pectoris daily, with pain referred over the area shown in Figure 2. Prolonged medical treatment had not given him relief, but his general condition in other respects was good. In our clinic we feel that cervical sympathectomy is an unphysiological and unsatisfactory operation. We hoped that the patient might live for many years and were not sure that an alcohol injection would give permanent relief. Therefore, we decided to remove his upper thoracic sympathetic rami and ganglia by the dorsal approach, but were uncertain as to how many segments would have to be resected. Paravertebral novocaine block of D<sub>1</sub> and D<sub>2</sub> on the left side stopped the attacks for thirty-six hours. A subsequent resection of these two ganglia by Dr. W. J. Mixter and myself gave him complete relief from his angina for nine months, when he died suddenly with an attack of right precordial pain.

In this instance, as well as in the preceding case, we were undertaking operations which to the best of our knowledge had not been tried before. But with the information obtained from the novocaine test, we felt quite confident that they would succeed.

CASE VI. A woman of sixty-two gave a five months' history of bloody sputum, weakness, dyspnea and loss of weight. For two weeks she had suffered from knife-like pains in her left shoulder and back. X-ray showed a large tumor in her upper chest and fluid displacing the right border of her heart 2 in. to the right of her sternum. A chest tap obtained a liter of serosanguineous transudate, but did not relieve her pain. Swetlow<sup>14</sup> had already shown that pain from carcinoma of the lungs and pleura could be relieved by paravertebral alcohol injection, but we were uncertain as to just how many segments needed to be blocked. Novocaine was, therefore, infiltrated in the region of the upper dorsal intervertebral foramina. When the first 4 were blocked, all the pain had disappeared. Without moving the needles, 6 c.c. of alcohol were injected into each. There was no recurrence of pain while she remained on the ward, but she has been lost track of since.

## II. DIAGNOSTIC NOVOCAINE BLOCK TO DETERMINE THE PATHWAYS OF PAIN IN THE EXTREMITIES

Painful amputation stumps are notoriously difficult to desensitize; the same is true of causalgias and other obscure painful conditions which follow penetrating wounds, prolonged sepsis and trauma of the hands and feet. Amputation, neurectomy and even extensive section of the posterior roots have often failed to give relief. In the simpler types it is often desirable to find out which nerve trunk is carrying the painful stimuli. The following is a case in point:

CASE VIII. A man with thrombo-angiitis obliterans had had a Gritti-Stokes amputation. Just as he was ready for his artificial leg he had fallen and struck on the tip of his stump. This had set up severe pain of two sorts: (1) Lancinating twinges of pain in his phantom toes; (2) a steady burning ache deep down in the tip of his stump.

Novocaine injection of the sciatic at once stopped the shooting pains in his phantom toes and alcohol injection of the nerve made this permanent, but the deep pain under his patella persisted. When the anterior crural and lateral femoral cutaneous nerves were blocked, there was complete skin anesthesia of the stump, but the deep ache and tenderness still persisted and prevented his using an artificial leg. As a last resort, I did a diagnostic infiltration of his obturator nerve. The pain disappeared at once with the novocaine and has not recurred for nine months. During this period he has been bearing full weight on an artificial leg eight hours a day selling newspapers.

In this case the site of pain beneath the patella might have made us suspect the obturator nerve, but there are other types of amputation stump and traumatic neuritis which are far more difficult to treat. I recall one such case in Leriche's clinic in Strasbourg, where an ex-soldier had had 5 successive amputations starting with a crushed finger and ending with a frightfully painful stump of his upper arm. When a posterior root section had failed to help him, he came to the clinic threatening suicide if he could not be relieved. He was

finally cured by the removal of his stellate ganglion. This type of case, which may start with a relatively minor wound or

CASE XII. A man of thirty crushed the terminal phalanx of his right index finger in a box-making machine in May, 1929. The tip

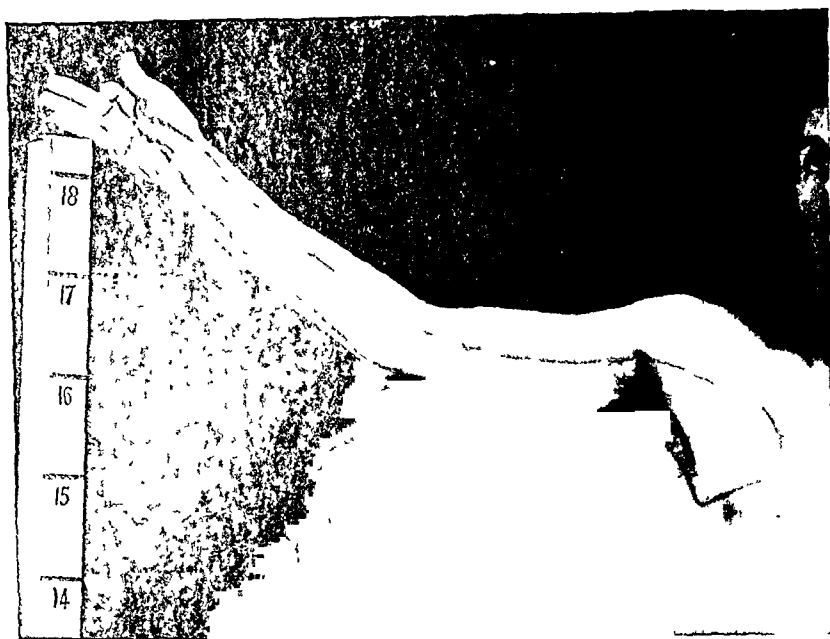


FIG. 3. Area of distribution of pain in CASE XII. Relieved by novocaine infiltration and excision of first and second dorsal ganglia.

trauma, is characterized by diffuse tenderness not limited to any known distribution of the cerebrospinal nerves. There is frequently an accompanying state of vasomotor spasm involving the entire extremity. Here is a rather typical case:

of the finger was amputated and a rather poor stump resulted. He came into the hospital in October complaining of severe aching pain shooting up the inner aspect of the forearm. When it became most severe, it radiated into his right chest (Fig. 3). During the summer the

TABLE IB  
NOVOCAINE BLOCK TO TEST EFFECT ON PAIN IN THE EXTREMITIES

Case	Disease	Injection	Result	Temperature	Operation	Success
VIII	Painful Gritti-Stokes amputation.	Femoral sciatic obturator	Phantom foot pain and pain under patella relieved.		Alcohol injection of sciatic.	Yes
IX	Painful Gritti-Stokes amputation.	Sciatic obturator	Relief pain for 2 hrs. (Result here misleading).		Obturator cut.	Yes
X	Traumatic amputation of four fingers.	D <sub>1</sub> and D <sub>2</sub>	Complete relief for 24 hours		Obturator nerve cut.	No
XI	Causalgia from puncture wound of hand. Vasomotor spasm.	D <sub>1</sub> and D <sub>2</sub>	Complete relief for 24 hours.	+16.5°	Resection of multiple neuromata in scar.	Yes
XII	Causalgia from crushed finger. Vasomotor spasm.	Digital nerves	No relief.	+16°	Not severe enough for operation.	
XIII	Painful fourth finger (cause unknown) vasomotor spasm, hyperhydrosis.	D <sub>1</sub> and D <sub>2</sub>	All pain stopped.		Dorsal ganglion-ectomy.	Yes
XIV	Painful traumatic arthritis of wrist.	Digital nerves.	Relieved pain in finger.	+17.3°		
XV	Old rupture of supraspinatus tendon. Pain in shoulder.	D <sub>1</sub> and D <sub>2</sub>	Warm dry hand, pain unchanged.		To have dorsal ganglion-ectomy soon.	
XVI	Vasomotor instability with burning pain in feet.	D <sub>1</sub> and D <sub>2</sub>	All pain stopped for 5 days		No operation.	
		L <sub>1</sub>	No effect on pain. Hand warmed.	+15.6°	Bilateral lumbar ganglion-ectomy.	Yes
			Burning stopped.			

hand had become moist, cyanotic and so cold that he had to wear a glove on all but the hottest days. As the cool weather came on, he found himself unable to work at all. Had the pain been due to a neuroma or any local cause, blocking the base of his finger with novocaine should have relieved it. This procedure had no effect on the ache in his arm. A paravertebral infiltration of D<sub>1</sub> and D<sub>2</sub>, however, warmed his hand and stopped the pain for over twenty-four hours. As no anesthesia is produced in the arm by this injection, it proved that the sympathetic nervous system was responsible for the entire syndrome.

As this was one of the first cases in which I had tried this test, I did not dare undertake at once such a radical procedure as dorsal ganglionectomy. A reamputation of his finger through the middle of its proximal phalanx was done instead. This resulted in a very good stump, but the general condition of his hand and arm was made worse. He reentered in February, stating that in spite of a long course of baking and massage, he had remained totally

incapacitated. Excision of his first and second thoracic ganglia has resulted in complete relief of all his symptoms.

CASE XVI. A young Russian Jewess, who during the Revolution was exposed for long periods to extreme cold. Following this she developed chilblains in her feet which caused such burning pain that she was unable to work during the winter of 1928-29. She also showed a continuous vasomotor spasm of her hands and feet, but this bothered her very little in comparison to the pain. Before undertaking lumbar ganglionectomy, we wished to know whether interruption of the sympathetic nerves would relieve her pain as well as warm her feet. Novocaine injection of her left lumbar sympathetic trunk caused the burning pain to disappear in the injected leg for the remainder of the day besides warming the foot 15° F. She readily accepted operation; it was performed six months ago and has enabled her to work through the past winter without any further difficulty.

TABLE IC  
NOVOCAINE BLOCK TO TEST EFFECT ON CIRCULATION

Case	Disease	Injection	Result	Temperature	Operation	Success
xvii	Raynaud's disease with gangrene of two fingers.	D <sub>1</sub> and D <sub>2</sub>	Cyanosis and sweating disappeared.	+11°	Dorsal ganglionectomy.	Yes
xviii	Raynaud's disease with atrophy of two fingers.	D <sub>1</sub> and D <sub>2</sub>	Cyanosis and sweating disappeared.	+23.4°	Dorsal ganglionectomy.	Yes
xix	Continual vasomotor spasm four extremities. Painful edema left leg.	Spinal	Cyanosis and sweating disappeared.	+12°	Bilateral lumbar ganglionectomy.	Yes
xx	Ulcer in sole of foot. Poor circulation, sequel to poliomyelitis.	Spinal	Sweating disappeared.	+16.5°	Bilat. lumbar ganglionectomy.	Yes
xxi	Poor circulation, sequel to poliomyelitis.	Sciatic	Sweating disappeared.		No operation.	
xxii	Erythema induratum with open ulcers.	Spinal	Cyanosis and sweating disappeared.	+17.7°	Bilateral lumbar ganglionectomy.	Yes
xxiii	Thrombo-angiitis obliterans. Superimposed vasomotor spasm. Non-healing amputation of toe.	Spinal	Slow warming and improvement of cyanosis.	+12°	Lumbar ganglionectomy.	Yes
xxiv	Thrombo-angiitis obliterans. No vasomotor spasm. Non-healing amputation of toe.	Spinal	No change.	0	Amputation.	
xxv	Chronic vasomotor spasm of hands. Pain in finger tips. Early scleroderma.	D <sub>1</sub> and D <sub>2</sub>	Warmed hands. Stopped pain. None.	+19.5°	Dorsal ganglionectomy.	Yes*
xxvi	Chronic vasomotor spasm of hands. Pain in fingers and wrist. Moderately advanced scleroderma.	D <sub>1</sub> and D <sub>2</sub>	Warmed hands. Stopped pain. None.	+21°	To have operation soon.	
xxvii	Advanced scleroderma. Cold hands.	D <sub>1</sub> and D <sub>2</sub>	No effect. Little change, arteries of fingers apparently compressed.	+3°	No operation.	
xxviii	Birth injury with spastic cold arm.	D <sub>1</sub> and D <sub>2</sub>	No change in spasticity.	+23°	No operation.	
xxix	Compression fracture D <sub>12</sub> . Spasticity. Cold, ulcerated feet.	Sciatic	Hyperemia of foot.	+26.7°	Bilateral lumbar ganglionectomy.	Yes

\* Too early to tell effects on fibrosis.



### III. DIAGNOSTIC NOVOCAINE BLOCK TO DETERMINE THE EFFECT OF SYMPATHECTOMY IN INCREASING PERIPHERAL CIRCULATION\*

In the arm, a paravertebral novocaine injection of the upper two dorsal sympathetic ganglia gives a rise in peripheral skin temperature which has consistently corresponded within a few degrees to that produced by dorsal ganglionectomy. The value of the test is illustrated by this case:

CASE XVII. A woman forty-six years old had Raynaud's disease which had caused terminal gangrene of 2 fingers. The atrophy of the skin was so marked and the circulation to the fingers so poor, that there was considerable doubt as to how much improvement would take place from removal of the stellate and second dorsal ganglia. This was investigated by a novocaine injection of these ganglia, which caused a rise of  $11^{\circ}\dagger$  in the finger tips. Subsequent operation has duplicated the increase in temperature nearly exactly.

TABLE II  
MRS. T. VASOMOTOR SPASM 4 EXTREMITIES

	Before Paravertebral Injection		After Paravertebral Injection		Postoperative 1 Month	
	R	L	*R	L	*R	L
Tip Thumb .....	80.0	77.4	91.0	83	92.0	80.8
Dorsum Hand ..	84.0	87.0	91.0	88	91.3	82.9
Mid. F. A ..	88.4	88.9	93.4	92.6	95.0	89.6
Room .....	74		75		73	

In the case of the legs, the effect of interrupting the vasomotor pathways can be determined in three ways, by:

Spinal subarachnoid block.

Injection of the lumbar sympathetic ganglia.

Peripheral nerve block.

1. *Spinal Subarachnoid Block.* In any spinal anesthesia where numbness rises to the xiphoid, all the sympathetic nerves

\* The technic and results of diagnostic novocaine block for determining the effect of ganglionectomy in cases of peripheral circulatory disease are given in detail in another publication.

† All temperatures are given in degrees Fahrenheit.

to the lower extremities are temporarily paralyzed. As a result the legs become flushed, dry and hot. This reaction lasts as long as the anesthesia. Spinal block has proved most useful as a quantitative test for showing the increase in peripheral surface temperature which will follow lumbar ganglionectomy.

CASE XX. In a boy of sixteen, who had had poliomyelitis eleven years before, an attempt had been made to straighten out a bad claw foot deformity by manipulation with a Thomas wrench and fixation in a plaster boot. When the plaster was removed a deep ulcer had developed on the ball of his foot. Attempts at skin grafting had failed. As the foot was continuously cold and discolored, it was very important to know whether the circulation could be increased by lumbar ganglionectomy. Spinal anesthesia was given and five minutes later the temperature of the toes had risen from room temperature of  $78^{\circ}$  to  $95^{\circ}$ . The operation was performed under the same spinal anesthesia and resulted in a permanently hot foot. The ulcer was subsequently grafted and has remained healed.

CASE XXIII. In a case of thrombo-angiitis obliterans, where the big toe had been removed for gangrene, the amputation stump had failed to heal. Intravenous injection of foreign protein, as recommended by Brown<sup>15</sup> had failed to increase the peripheral circulation. Before we considered a reamputation, however, a diagnostic spinal anesthesia was given. The skin temperature at the base of the ulcer rose slowly  $12^{\circ}$ . Although it required forty minutes to do this, the increase in temperature was reproduced exactly by excision of his second to fourth lumbar sympathetic ganglia and the ulcer was slowly healed.

2. *Injection of the Lumbar Sympathetic Ganglia.* Posterior splanchnic block also produces an increase in surface temperature of the legs which corresponds closely to the results obtained by ganglionectomy. As the spinal anesthesia test is simpler, we block the sympathetic trunk only when we wish to know the effect on pain as well as temperature (see CASE XVI).

3. *Peripheral Nerve Block.* Blocking the peripheral nerves produces a maximum

hyperemia in the area of their innervation. This is illustrated in Figure 4 where spinal anesthesia gave no further increase in

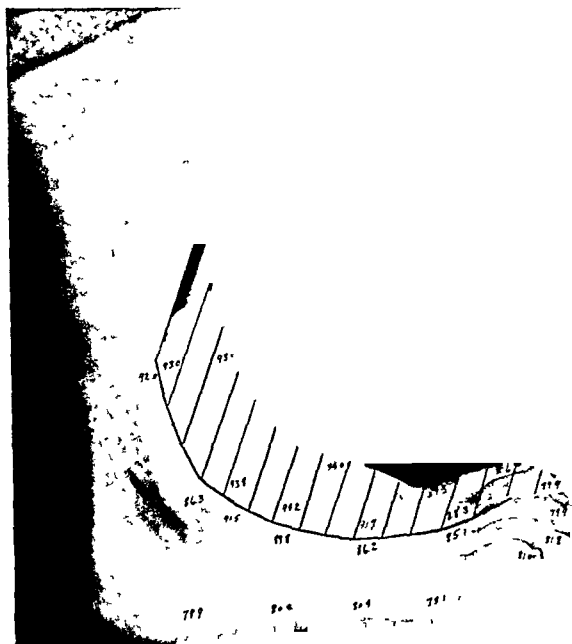


FIG. 4A. Foot in case of thrombo-angiitis obliterans. Anterior and posterior tibial nerves as well as superficial peroneal nerve have been blocked. This has resulted in relief of vasomotor spasm and hyperemia of sole and dorsum of foot. Lines mark zone of anesthesia on dorsum of foot.

temperature in the foot where the anterior and posterior tibial, as well as the superficial peroneal nerves were already blocked.

CASE XXIX. I have recently taken advantage of this observation in a man with extremely cold ulcerated feet following a fracture of his twelfth dorsal vertebra with spastic paraplegia. A spinal fusion made lumbar puncture impossible. Injection of his sciatic nerve showed that paralyzing the vasomotor fibers to the foot caused an increase in temperature in the toes from  $68.8^{\circ}$  ( $7^{\circ}$  below room temperature) to  $95.5^{\circ}$ .\*

#### COMMENT

Table I gives a summary of all the cases in which novocaine has been used to block the cerebrospinal or sympathetic pathways to determine the effects of operation. In only one instance have I been unable to block the desired nerves. There have

\* Bilateral lumbar ganglionectomy has raised the temperature of both feet to this level.

been no complications. The patients themselves have minded the test very little; in fact two volunteered the informa-

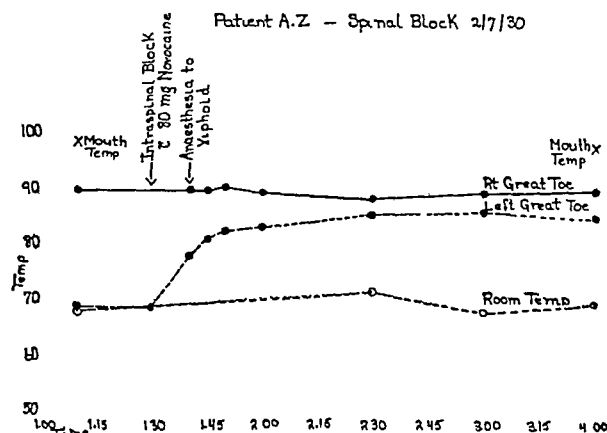


FIG. 4B. Effect of spinal anesthesia. No further rise of temperature in foot where peripheral nerves are blocked. Marked rise in uninjected side. This shows that peripheral injection is as good a method as spinal anesthesia for testing the effect of ganglionectomy on circulation.

tion that paravertebral injection of the upper dorsal sympathetic rami was much less disagreeable than the intravenous foreign protein test for vasomotor spasm. Novocaine infiltration of the sympathetic rami and ganglia has a further advantage over the intravenous foreign protein test; it duplicates exactly the effects of operation, whereas the latter gives little help in the matter of pain and is at best only a qualitative test for the effect of operation on circulation. In fact in our hands it has sometimes been definitely misleading. (CASE XXIX.)

The only difficulty with the nerve injection method is that novocaine is so diffusible that it may block more nerves than one expects. This is particularly true in blocking sympathetic rami. In the thoracic region the novocaine can easily diffuse downwards in the loose connective tissue between the pleura and the spine, thereby infiltrating the third and fourth rami when only the first and second have been directly injection. However, I have never seen it diffuse upward and involve the brachial plexus. The test is therefore quite accurate in differentiating pain involving the sym-

pathetic nervous system from the more usual variety which enters the cord over the posterior roots of the brachial plexus.

cases of causalgia or amputation stump neuralgia. In blocking the lumbar sympathetic trunk, it is also possible for the

*Novocain Block of Sciatic Nerve (P. F. C.)*

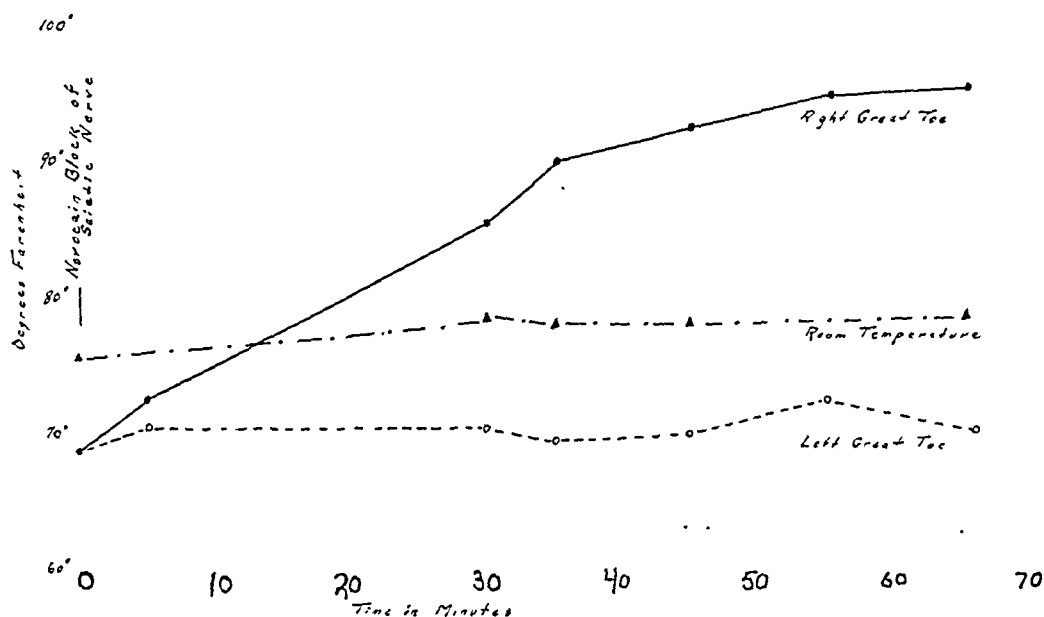


FIG. 5. Elevation in surface temperature of great toe in CASE XXIX following novocaine block of sciatic nerve.

This is a very important point, as there are numerous cases on record where all

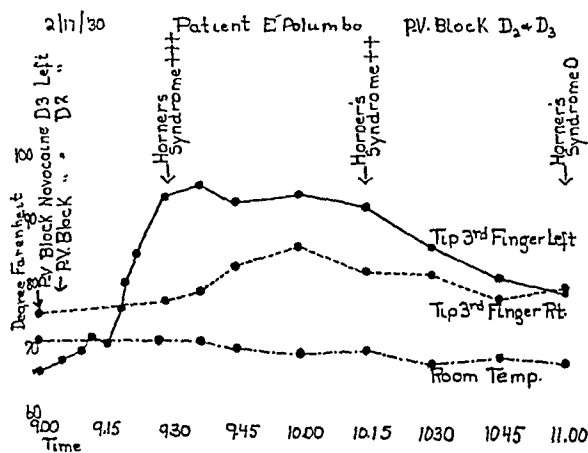


FIG. 6. Paravertebral novocaine injection of upper dorsal ganglia in CASE XXV, showing maximum rise of temperature in left arm. Delayed rise in right arm due to diffusion of novocaine across to right sympathetic trunk.

the posterior roots of the brachial plexus have been cut without relieving severe

novocaine to diffuse down along the psoas muscle and produce an anesthesia of the main nerve trunks to the legs; this can spoil the selectivity of the sympathetic block. The solution of this difficulty is to use every effort to get the needle as close as possible to the desired sympathetic structures and then to use the smallest possible amount of novocaine. For selective injection of the thoracic sympathetic rami I would recommend using 2 c.c. of 2 per cent novocaine instead of the 5 c.c. of 1 per cent recommended by Labat for thoracic anesthesia. Similarly for the injection of the lumbar sympathetic ganglia, it is better to infiltrate only 10 c.c. of 2 per cent novocaine against the anterior-lateral aspect of the second lumbar vertebra than 50 c.c. of the 1 per cent solution recommended for splanchnic anesthesia. It is not necessary to infiltrate the lower lumbar ganglia to secure a sympathetic paralysis of the leg, as the lowest white

ramus communicans joins the sympathetic trunk at its second lumbar ganglion.

The rapidity of onset and the duration of the effects of novocaine are interesting. When the sympathetic ganglia are injected, the onset of the vasodilatation in cases of vasomotor spasm usually becomes noticeable in fifteen minutes and may last anywhere from one to two hours (Fig. 6). With the spinal anesthesia test, however, the leg in cases of vasomotor spasm warms up as soon as the anesthesia ascends above the umbilicus, in two to five minutes as a rule (Fig. 7a). But in patients with thrombo-angiitis obliterans the rise, if the arteries are capable of dilating at all, is much less in degree and slower in onset, often requiring three-quarters of an hour to reach its maximum (Fig. 7b). In the instances where pain is blocked, the relief when the peripheral nerve trunks are involved usually lasts as long as the regional anesthesia, but where the pain is referred over the sympathetic nervous system the pain disappears quite constantly for from twenty-four to thirty-six hours. I have no explanation for this.

I feel that there are great possibilities for this test, both for practical work in the clinic and for research in nerve physiology. It can foretell that a certain type of nerve section or posterior root section will not relieve a patient's suffering; or on the other hand, enable the surgeon to perform such a radical procedure as sympathetic ganglionectomy with a definite assurance that it will stop an unusually perplexing type of pain. It can tell the surgeon just how many nerves or ganglia he must interrupt to secure the result he wishes, also exactly how much he can increase the circulation in an extremity with any type of circulatory insufficiency. Finally, it gives the patient a thorough demonstration of what operation can accomplish and an opportunity to decide for himself whether he wishes to have it performed.

The use of novocaine in determining the pathways of visceral pain, as I have

said before, is to be credited to Von Giza; its use in predicting the effect of sympathetomy on circulation and pain in the

#### Temperature of Toes after Spinal Anesthesia

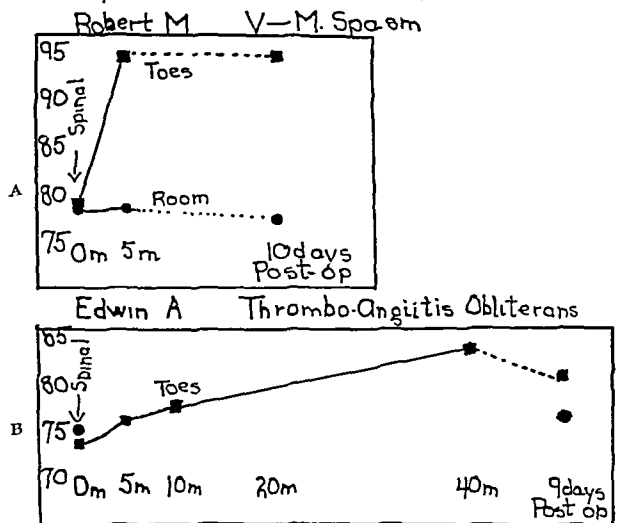


FIG. 7A. Rapid rise in temperature of legs following spinal anesthesia in patient with vasomotor spasm. CASE XX.

FIG. 7B. Slow rise in temperature in patient with thromboangiitis obliterans. CASE XXIII.

extremities is based on work recently done on the Surgical Services of the Massachusetts General Hospital.

#### SUMMARY

Diagnostic novocaine block is a safe and simple procedure. We have used it to date in 29 cases with only a single confusing result.

It gives both the surgeon and the patient an exact idea of what a proposed operation on the peripheral nerves or sympathetic ganglia is capable of accomplishing.

It shows just which spinal nerves or sympathetic rami are conducting pain and how many must be interrupted to desensitize the patient.

In peripheral circulatory disease novocaine block of the regional vasomotor nerves shows in a quantitative fashion how much circulation can be improved by ganglionectomy.

The test has proved to be of the greatest value in planning new ways of relieving pain in angina pectoris, aneurysm, tabes dorsalis, causalgia, amputation stump

neuralgias, and other conditions of unknown cause.

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#### DISCUSSION

DR. BYRON STOOKEY: Dr. White has presented a very valuable method in determining just what neurosurgical procedure shall be done, and what the results of this neurosurgical procedure will be. The use of typhoid vaccine as he has very rightly said, as a matter of

purely a qualitative thing, and novocaine, has permitted him to determine with precision just what the temperature of that extremity would be after the ganglion has been removed or when the section has been performed.

That contribution, had he come to us to present that and that alone, would have been, in my opinion, a tremendous contribution, one well worth listening to, and sufficient in itself. But in addition to that he has also shown that there are other procedures which may be used which heretofore so far as I am aware have not been employed, namely, the injection of novocaine in the subarachnoid space to prove that this also will give a sympathetic block which, of course, it does. He has merely applied a well-known anatomical fact to a definite clinical problem, presented it, and after he has presented it, all of us who have heard it have said, why have we not done that before? Which is always the fact when any great truth has been presented. The facts have all been before us but we have never had enough sense to put them together. Dr. White has put them together for us. It is certainly a great value to be able to tell the patient that this operation is going to succeed, that you are able to give to him that relief which has been obtained by novocaine injection, whether it be of the ganglia or in the subarachnoid space or in the nerves.

I am extremely interested, in addition to his work demonstrating the advantages of sympathetic paralysis and in the realm of circulatory disturbances, in his presentation as to what he can do for the relief of atypical forms of pain. The case of the man who had an amputation of his distal phalanx, which he cited, is extremely interesting. Subsequently Dr. White apparently was forced to take off the second phalanx, and then afterwards he proved that the pain was a pain referable to the sympathetic system, and not to the somatic system.

I believe that the pain this man had and the other painful affections which Dr. White has relieved, are due primarily to vasorestriction and I should like to know whether Dr. White made any temperature studies of some of these atypical cases where he has relieved the pain by sympathetic section.

I am not in accord with Dr. White's viewpoint entirely as to the afferent pathway of the sensory fibers of the sympathetic. We all are certain that the sympathetic ganglion cells lie in the dorsal ganglia. They are evaginations

from the neural tube at the time when the neural tube is beginning to close, and when the formation of the ganglionic crest is beginning and the sympathetic ganglion cells lie in the dorsal ganglion, not in the sympathetic ganglia. The sympathetic ganglia is made up of effector cells, that is motor cells, and not sensory cells, to the best of our anatomical knowledge.

If Dr. White has any additional information in this regard, I shall be very much interested as a neural anatomist. But I believe that if the sympathetic ganglion cells lie in the dorsal spinal ganglia, and you remove the sympathetic ganglia, you are removing the motor cells. It would be comparable, so far as its effect is concerned on the cells themselves, of cutting out the ventral horns of the spinal cord, rather than the dorsal spinal ganglia, for these are essentially extruded ventral horn cells.

But what you do in removing the sympathetic ganglion is not only removing these cells, but you remove the sympathetic afferent fibers that pass through the ganglia. In other words, you are cutting, I believe, the fibers from the afferent ganglion sympathetic cells that lie in the spinal cord and, therefore, of course, affect a loss of pain. But you have not removed, I believe, the cell body, nor have you gone proximal to the cell body, and between it and the spinal cord which I believe is an essential for permanent relief of pain. At least that has been our experience in other forms, and I do not see why this should differ.

Therefore, he might rightly pose the question to me of how then have I relieved the pain? "I have presented abundant evidence," he might say, "of having relieved these patients of pain," with which I entirely agree. I merely perhaps disagree with him as to how he has accomplished it. I think he has accomplished it because he has destroyed the effector side of the cell, relieved vasomotor spasm and has produced a vasodilatation, and thereby has relieved the patient of the pain which is due to an interference with the circulation.

DR. GASTON LABAT: It is very gratifying to note the progress which nerve-blocking has made in recent years. From the elementary principles of local anesthesia have evolved the elaborate procedures of regional anesthesia. New fields have just been opened whose exploration is made possible by increased application of physiological principles to the practice of nerve-blocking. Greater knowledge of anatomy and thorough familiarity with the

injection technic have widened the avenues leading to success.

During the last ten years we have been actively engaged in improving the technic of regional anesthesia, including subarachnoid block, using these procedures more for surgical purposes than as a means of diagnosis or treatment.

In January 1929, our interest was aroused by Dr. Woodbridge's inquiry relative to alcohol blocking of the sacral nerves by caudal or trans-sacral injection. My previous experience with neocaine and alcohol block dates as far back as 1917, at which time I attempted to relieve the pain of angina pectoris by the injection of 80 per cent alcohol. Neocaine injection of the splanchnic nerves for the relief of gastric crises was also performed by us nine years ago at the Mayo Clinic. The results were not very encouraging.

Since 1917, we have repeatedly used neocaine in solutions of  $\frac{1}{2}$ , 1 and 2 per cent in the treatment of sciatica, injections being made in the sacral canal. For the last three years, we have added alcohol to the 1 per cent solution, occasionally to the 2 per cent solution of neocaine with varying results, the percentage of alcohol varying from 5 to 25 per cent. Motor function has invariably been affected immediately after the injection of a 1 or 2 per cent solution, necessitating hospitalization of the patient for twenty-four hours. Some of the injections were made in the patient's home.

The occasional influence of sacral block by the caudal route on the innervation of the sphincters, particularly the anal sphincter, was too disagreeable to justify the continuance of such a procedure. The fact that motor function was interfered with in both lower extremities has also had a stimulating effect on our search for a better procedure.

In this discussion, it is impossible to do more than mention the fact that in a great percentage of cases, after a correct diagnosis, injection of the first sacral nerve by the trans-sacral route has been sufficient to miraculously transform an apparently very sick patient into one with a smile of relief.

The quantity of solution injected varied between 4 and 6 c.c., the concentration of alcohol between 10 and 50 per cent. The relief in every case has been instantaneous and perfect after a single injection, so that we would be justified in calling this a better procedure than the caudal injection which necessitates large

amounts of fluid and interferes with a wider nerve distribution. In 1 case, however, the injection of the first sacral left a certain area in which pain disappeared by the injection into the sacral canal of 25 c.c. of a 2 per cent solution of neocaine without alcohol, the patient being instantly relieved.

Many patients suffering from neuralgic pain of obscure origin and from chronic arthritic conditions find no relief in the most varied treatments applied by the family physician. As a last resort, the use of morphine transforms these patients into drug addicts.

For the last year, Dr. M. Greene of Brooklyn and myself have been studying the application of nerve-blocking to these cases. Up to now we have had 21 cases under observation; a great percentage are patients suffering from pain in territories supplied by the external cutaneous and anterior crural nerves, sometimes the obturator nerve as well. Tenderness, as revealed by the electric percussion hammer, was sometimes along the path of these nerves, but occasionally along obscure lines rendering accurate diagnosis rather difficult. X-rays invariably showed productive osteoarthritis of the dorsolumbar and lumbosacral vertebrae. Many of these cases come under the general formula: blocking the second and third lumbar nerves with neocaine and alcohol. In some of the cases, tenderness along the distribution of the sciatic nerve called for the blocking of the first sacral nerve as well. All these injections were made with a 50 per cent concentration of 95 per cent alcohol.

There were 3 cases in which the upper extremity was involved; in 2 of them the brachial plexus was blocked over the clavicle with 25 c.c. and 15 c.c. respectively of 2 per cent neocaine solution with alcohol in a concentration of 33 per cent. Motor function in both cases was greatly diminished, almost abolished for a few hours following the injection, but was completely restored the following day, the pain complained of having disappeared entirely. In 1 case of pain in the upper extremity, the blocking of the branches of the brachial plexus was thought advisable. It was performed in two sessions; the ulnar nerve was blocked at the elbow and median nerve at the wrist on the first day. A few days later the musculospiral nerve was blocked at the bend of the elbow. Alcohol was used with neocaine in a concentration of 33 per cent. The results have been perfect so far.

Three cases of trans-sacral block with 50 per cent alcohol are still under observation. They refer to carcinoma of the rectum, uterus and vulva following the application of radium emanation seeds. Blocking in the case of the vulva does not seem to have had the results which were obtained in the other 2 cases. It is impossible to predict how long will be the relief of pain in the cancer cases, but it may be possible to subsequently block other nerves.

DR. STERNE: I would like to ask Dr. Woodbridge whether in a case of angina, where he blocked the first or sixth thoracic ganglia, whether the patient had a horny syndrome, and whether the patient complained of a sweating on the opposite side of the chest.

I have had some experience in blocking the thoracic ganglia in a case of cancer of the chest wall, involving the head of one rib. The patient had been on morphine, about 8 grains per day, without relief, was bedridden, and gradually going downhill. The minute his ganglion was blocked, he was able to eat and he was able to get out of bed, and it lasted almost a year, until the disease killed him.

The other case that I had of cancer was one in which the entire abdomen was filled with carcinoma, arising probably from the ovary. I blocked the lower thoracic and all the lumbar nerve roots on both sides, with some relief of pain, but the patient only lasted two weeks. During that time she was definitely relieved of most of the pain, but she still had some pain which required medication.

I have had recently 2 cases of thromboangiitis which I have blocked by injecting the twelfth, first and second lumbar nerve roots on the same side, with definite satisfactory results. That procedure involves not only the sympathetic fibers, but also some somatic nerves which send fibers to the blood vessels of the lower extremity. The first patient that I treated is now five weeks old, and his foot has remained warm ever since the procedure. The second is two weeks old and his foot likewise is warm.

These men's feet were absolutely cold for several years, and they were on the verge of committing suicide because both had had previous amputations of the opposite limb. The application of block to old myelitis cases is very important because I think we will be able to do a lot towards improving the circulation of the limbs of these children who are so unfortunate.

DR. PHILIP D. WOODBRIDGE: In regard to Dr. Sterne's question about Horner's syndrome: The patient unfortunately lived quite a distance away and so went out of my direct observation. I am therefore unable to answer the question.

DR. WHITE: Just a word about the subject Dr. Stookey brought up concerning these patients who have causalgias and major amputation stump neuralgias. I saw three or four in Strasbourg with Dr. Leriche. They had occurred following shrapnel wounds of the hands or puncture wounds over a major artery, in 1 case following a chronic sepsis just above the wrist. In most of them a primary low amputation had been done, then one or more neuromas had been exised, and when that failed to give permanent relief, the nerves had been interrupted higher up. All these measures failing, one or more re-amputations had been done, each amputation stump successively becoming painful. One man had five amputation stumps and ended up with a painful shoulder.

Leriche had started out by doing posterior root sections, and he failed three out of four times to relieve them of their pain, although he was sure he cut every posterior root from the fifth cervical to the first dorsal. W. J. Mixer in Boston had had an exactly similar experience in 2 or 3 cases. Leriche had carried it one stage further and, when he failed by posterior root section, he had removed the stellate ganglion through the neck and that had, so far as I know, always succeeded. I saw 2 of the cases and it had succeeded very well. It is very difficult for me to say just what happens here; why in a case of that type we do not get relief when we cut all the somatic fibers we know of coming from the extremity and why we should then get relief by removing the sympathetic ganglia. You see that this happened in the patient whom I spoke about with the tabetic crises. He had had his posterior roots cut from the seventh dorsal to the eleventh dorsal. Theoretically, all the innervation of the stomach and abdominal wall had been interrupted, yet he continued to have pain. He did not have a cold abdominal wall. I do not see how we can work vasomotor spasm into his case. Yet, posterior root section had not given relief while the removal of the sympathetic pathways to the stomach did give relief.

That gave us the choice of one or two possibilities, it seems to me. Either some of this pain can come over anterior roots, or the sympa-

thetic innervation from the viscera and the arteries covers a great many more segments than the corresponding somatic innervation.

Langley has shown that in the arm the vasomotor fibers do not come off the roots that correspond with the brachial plexus, but that they leave the cord from the fifth to the ninth dorsal segments; they then rise in the sympathetic dorsal trunk until they get to the first and second ganglia and their grey rami come off and go to the trunks of the brachial plexus. If the sympathetic motor fibers follow that course, it is possible that the sensory fibers follow a similar route.

I do not want to imply that these pain fibers are necessarily sympathetic nerves. Ranson has shown that they are medullated, that they have their cells of origin in the posterior root ganglion. They run through the sympathetic ganglia without any synapses directly to the viscera. It is perfectly possible that they are cerebrospinal pathways. But from the point of view of the surgeon the point of greatest importance is that they run in the sympathetic trunks.

That is the most satisfactory explanation I can give, but I think you will have to admit that in some of these cases as in the aneurysm and in the tabetic crises, it is pretty difficult to account for the pain as due to any motor effect. And if the pain were due to a motor effect, how could it get back to the sensorium if the posterior roots had been cut, unless it came over some unusual course?

In all the cases of hand pain it was very obvious that the hand was cold. In these it might be justifiable to say that the vasospastic element had something to do with the pain. The peripheral skin temperatures in all those cases were very close to the temperature of the room, whereas the temperature of the normal hand in a room of 70° F. is usually about 85° F.

I was very much interested in Dr. Sterne's description of that patient with thromboangiitis obliterans. We have been trying to find out what communicant rami carry the vasomotor fibers to the legs. I would like to know if he took the skin temperatures in that case and how much they were increased?

DR. STERNE: We did not take any accurate measurements, but the difference was so perceptible it was noticed by the patient. Both patients the evening that the injections were done said that their feet were so warm that they had to throw the blankets off.



# THERAPEUTIC NERVE-BLOCK WITH PROCAINE AND ALCOHOL\*

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THE earliest form of alcoholic injection of peripheral nerves for therapeutic purposes is the one that is most commonly used and generally accepted today: that for the relief of trigeminal neuralgia. Since Schlösser's original publications,<sup>79-81</sup> the fundamental principles involved have been applied with varying success to a variety of ailments in diverse regions of the body. It is my purpose in this paper to assemble brief résumés of the more important work that has been reported from time to time in this field, and to present a few cases that have come under my care, selected to illustrate the favorable results that may be obtained.

## PARAVERTEBRAL AND OTHER PERIPHERAL NERVE INJECTIONS

*For Pain in the Head and Neck:* The pain of carcinoma of the face and neck may be relieved in a large portion of cases by alcoholic injections of the fifth nerve and of the cervical plexus. Both Fay<sup>19</sup> and Grant,<sup>25,26</sup> however, prefer rather major operative procedures on the nerves, such as intracranial neurectomy and cervical laminectomy with crushing of the posterior roots, as being more positive in their results. Grant found, however, that most patients prefer the alcoholic injections; indeed their choice seems somewhat justified in his reported results, for of 34 patients treated by injection none died and 62 per cent were relieved or improved, whereas in 10 who had operations, 70 per cent were relieved or improved, but 20 per cent died of operative complications. It would seem well to reserve operation for those cases in which repeated alcoholic injections have failed.

\* From the Lahey Clinic. Read before the Sixth Annual Meeting of the American Society of Regional Anesthesia, New York City, April 1, 1930.

The pain of carcinoma of the tongue, tonsil and base of the skull has also been successfully relieved by alcoholic injection of the branches of the fifth nerve.<sup>30</sup> With invasion of the nasal sinuses, relief is less sure,<sup>26</sup> and pain referred to the external auditory canal and the center of the pinna has baffled attempts at relief because of its involved and deeply-seated nerve supply.<sup>19,26</sup>

Attempts have been made to relieve spasmodic twitching of the facial muscles by alcoholic block of the seventh nerve, but the likelihood of causing paresis or temporary palsy makes this procedure of doubtful merit.<sup>23,30,81</sup> It would seem better to direct treatment toward the fifth nerve in most cases, as the twitching is usually a reflex response to stimuli transmitted by this nerve. In contrast to the usual injection treatment of trigeminal neuralgia, Sluder and Ruskin<sup>78</sup> have advised alcoholic injection of the sphenopalatine ganglion in cases in which both the fifth and the seventh nerves are involved, since both communicate with this ganglion.

## CASE REPORT

CASE 1. *Carcinoma of neck; alcoholic injection of cervical plexus and mandibular nerve; relief.* Male, aged sixty-three, came to the Clinic on July 31, 1929, with inoperable carcinoma of the epiglottis and of the right side of the larynx and pharynx, extending widely into the right side of the neck. Externally, the largest mass, about 6 cm. in diameter, lay just below the mastoid process. Other smaller subcutaneous nodules were scattered over this side of the neck. He complained of excruciating pain extending from in front of the right ear to the vertex, coming on one to three times daily and requiring morphine for relief. The pain was attributed to deep involvement of the

mandibular nerve. In addition there was pain, though less severe, referred to the right posterior quadrant of the neck, making it very difficult for him to find a comfortable position for sleep.

On August 3 the right cervical plexus was blocked first with procaine, then with alcohol. On account of the large carcinomatous mass below the mastoid process, the posterior approach had to be used in place of the preferred lateral route. Four c.c. of 2 per cent solution of procaine hydrochloride was injected at the tip of the transverse process of each of the second, third and fourth cervical vertebrae, followed by 4 c.c. of 80 per cent alcohol. The third branch of the fifth nerve was then approached through the mandibular notch and blocked at the foramen ovale with 2 c.c. of 2 per cent procaine followed by 3 c.c. of 80 per cent alcohol.

Two days after injection, sensation to pin-prick was diminished at only a few scattered points. On August 15, twelve days after treatment, although he complained of numbness over the right side of the head and of residual pain referred to the external auditory canal, yet he seemed very considerably relieved. There had been no return of the excruciating temporal pain, and the abolition of pain from the neck had given him the greatest comfort at night that he had had for weeks. Sensation to gentle wiping with cotton was unchanged, but sensation to pin-prick was definitely diminished over the areas supplied by the injected nerves. Relief from the more severe degrees of pain continued until his death five weeks later. Post-mortem examination showed epidermoid carcinoma of the pharynx and epiglottis, with invasion of the wall of the larynx, and with metastasis to the cervical and bronchial lymph nodes, the pleura, lungs and diaphragm.

In tuberculous laryngitis, the extremely distressing dysphagia, likely to lead either to partial starvation or to dependence on the cocaine spray, may be relieved by injection of the superior laryngeal nerves with 2 c.c. of 60 to 75 per cent alcohol,\* or of its internal branch with 0.5 to 2 c.c. of alcohol.<sup>20,36,53</sup> In either case, the solution should contain a small amount of cocaine or procaine. Fetterolf, Lukens and

Swetlow each report less than 10 per cent of failures with the method. Some patients experience increased pain for a few days following the injection and weakness of the pharyngeal muscles; occasionally this latter persists for some weeks. To avoid this complication, Fetterolf advises an interval of three days between the injections of the two sides.

*In Heart Disease:* A field with the greatest promise of a brilliant future is the treatment of cardiac pain by injection methods. As a consequence of Wenkebach's discussion of the dangers of existing operations for angina pectoris at a meeting of the German Society of Internal Medicine in 1924,<sup>6</sup> Brunn and Mandl tried paravertebral nerve-block with procaine, and reported some strikingly good and lasting results.<sup>8,54-56</sup> The use of alcohol instead of procaine, predicted by Brunn in 1926,<sup>7</sup> was first reported by Swetlow of New York City after his successful use of this procedure in 8 cases.<sup>87-90</sup> Since then others have written favorably of the method\* and the Whites and Richardson of Boston have been investigating it from both the laboratory and clinical points of view.<sup>72,97,98</sup> It is preferred to the numerous operative procedures that have been devised, because these frequently fail, being based on insufficient knowledge of the pain pathways, and because they present a very high mortality. With alcoholic block, on the other hand, no serious complications have been encountered and there has been no operative mortality. Furthermore, relief has been more constant, presumably because the point of attack, the rami communicantes, is the probable final common pathway of pain impulses to the cord regardless of their route up to this point. In selecting cases for this treatment, some prefer to limit themselves to those in which the distress is most severe and the disability greatest; they fear possible serious complications from placing alcohol so near to the pleura and the spinal cord.<sup>72,93</sup> Before making the injection, Swetlow

\* See Ref. 50, 51, 86, 88, 89.

\* See Ref. 13, 44, 71, 82.

maps out the zones of hyperesthesia and hyperalgesia and plans injection to anesthetize these zones, on the ground that the

second to fifth ribs and spread to the left shoulder and arm. Electrocardiographic examination confirmed the diagnosis of angina.

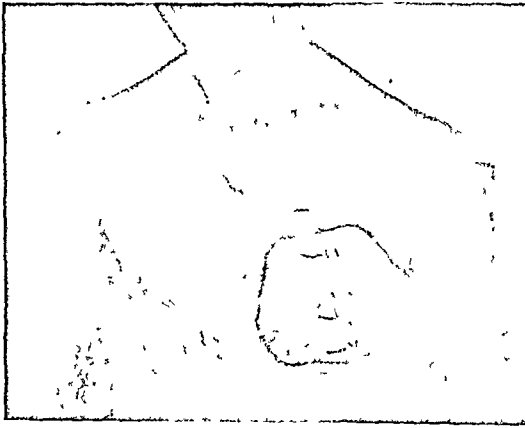


FIG. 1A



FIG. 1B.

FIG. 1. CASE II. Paravertebral alcoholic block for angina pectoris. Areas of complete and partial anesthesia are outlined. Upper border probably determined by overlapping of cervical nerves (not injected). Roman numerals indicate ribs. Dots indicate approximate points of injection.

nerve roots and dorsal root ganglia that supply them are presumably the ones kept in a state of irritation by bombardment of afferent impulses from the heart.<sup>90</sup> White, on the other hand, anesthetizes the upper five thoracic nerves as a routine.<sup>97</sup> Each nerve is injected with 5 c.c. of 1 per cent solution of procaine, followed by 5 c.c. of 85 per cent alcohol. Relief of pain follows promptly and persists for several months; other symptoms such as dyspnea are, of course, not influenced. Usually there is troublesome hyperesthesia for about six weeks following injection, which, however, is not as severe as that which follows sympathectomy. Horner's syndrome also is usually present (contraction of the pupil and narrowing of the palpebral fissure on the injected side).

**CASE II. Angina pectoris; paravertebral alcoholic block; relief.** Male, aged fifty-three years. Occupation: helper on moving van. When first seen, in May, 1929, he gave a history of precordial pain of one year's duration. This had gradually increased, so that he was then having attacks of severe anginal pain three to four times a week. It usually lasted from one to four hours, required morphine for relief, and had forced him to give up his work. The pain started in the left nipple line from the

There was increased sensitivity to pin-prick over the left chest anteriorly from the second to the fifth rib. On May 25 paravertebral block of the left first to sixth thoracic nerves was done, with 7 c.c. of 1 per cent solution of procaine hydrochloride on each followed by 6 c.c. of 80 per cent alcohol. Anesthesia was produced from the lower border of the second rib to the lower border of the fifth rib (Fig. 1). A report from his home physician four months later stated that troublesome hyperesthesia had been present for seven or eight weeks after the injection, but that there had been complete absence of attacks of pain referred to the precordium and left arm. Disability, however, had continued, because of moderate, steady pain in the chest, severe pain in the abdomen and nausea, all of undetermined etiology.

*In Disease of the Lungs and Pleura:* Relief may also be given in other intrathoracic diseases whenever suitable indications are present. Subcutaneous local anesthesia with 0.5 per cent procaine solution has been induced with success in a few cases of pleurisy and acute pericarditis.<sup>73,74</sup> The pain returns, but in less severe form, when the immediate effect of the procaine wears off. After the paravertebral injection of procaine, relief lasting for one day has been obtained in carcinoma of the pleura and in pneumo-

thorax.<sup>24</sup> In contrast to these evanescent results, lasting effect has been realized by Swetlow by alcoholic paravertebral block in 5 cases of tuberculous pleurisy.\*<sup>88,89</sup>

*In Disease of the Stomach:* In the therapy of diseases of the stomach, the most noteworthy achievement also appears to be that of Swetlow in relieving the pain of tabetic gastric crises by paravertebral alcoholic block.<sup>88,89</sup> He advises its use only when pain is the sole or main symptom. Operations previously devised to relieve this symptom-complex (Foerster and Moskowicz) had resulted in a large percentage of failures and a high mortality. Others have reported success in the use of procaine, both by paravertebral and by local subcutaneous injection, in abolishing the pain of gastric ulcer and carcinoma as well as of tabetic crisis.† The sixth to eighth and sixth to tenth thoracic nerves on both sides are those most commonly injected. The conclusion seems justified that paravertebral nerve-block by either procaine or alcohol is a suitable means of treating these conditions when merely palliation is sought, alcohol being chosen when it is desired to make the effect enduring.

*In Gall Bladder Disease:* In abolishing gallstone colic, very definite success has been reported by several writers by the use of procaine either paravertebrally‡ or subcutaneously.<sup>47,73,74</sup> In treating 27 patients who had repeated attacks of gallstone colic, Mandl found that in 22 of them, paravertebral procaine injection was followed by freedom of pain for from four months to two years; others<sup>24</sup> found that benefit lasted for a few days only. Injection is to be made in the vicinity of the right tenth or ninth and tenth thoracic nerves. If relief does not follow the blocking of these nerves, it is evidence that the disease has spread beyond the limits of the biliary tract.<sup>24,42,43</sup> The injection has been found to be of considerable value in

the control of postoperative pain, especially when this brings about inhibition of the cough reflex and thereby endangers the patient's condition.<sup>42,43</sup> Aside from this use, its field would appear to be limited to tiding patients over until operation, relieving patients when operation is contraindicated, and serving as an aid in differential diagnosis. The reports of lasting relief from the injection suggest the possibility that it may aid the passage of calculi by eliminating reflex spasm and permitting normal peristalsis.

*In Renal Disease:* In cases of renal or ureteral stone and of reflex oliguria, noteworthy effects have been produced by the induction of regional anesthesia. Renal colic recurring in a succession of attacks has been relieved for periods of six to fourteen months, and functional anuria, such as that following prostatectomy, has given way to polyuria, after procaine block of the twelfth thoracic and first lumbar nerves.\* Studies of its action in both the laboratory and the clinic have indicated that, when these nerves are blocked, the blood supply to the kidney and the amount of excreted urine are both increased, the amount of dissolved substance in the urine is increased (always absolutely increased, occasionally even relatively), ureteral spasm is abolished, and peristaltic waves are increased in frequency and vigor.† These various factors would obviously aid either nature or the cystoscopist in the expulsion or removal of a stone, and would occasionally have a salutary effect when urinary excretion was seriously diminished without corresponding structural damage to renal tissue.

CASE III. *Undiagnosed pain of right flank; paravertebral alcoholic injection; relief.* A male patient, aged forty-seven, came to the Clinic in December, 1928, complaining of pain in the right arm and shoulder. Later this gave place to increasingly severe pain in the thoracolumbar region of the back and flanks. Careful general examination as well as neurological, orthopedic, gastroenterological, cardiac and

\* He also reports treating 2 cases of malignant disease of the pleura, but does not state the results.

† See Ref. 40, 42, 43, 47, 54, 74.

‡ See Ref. 8, 24, 42, 43, 54.

\* See Ref. 8, 39, 42, 43, 54, 73.

† See Ref. 39, 52, 63, 100.

pulmonary examinations failed to reveal any adequate cause, and various forms of treatment failed to bring relief. In July, 1929, the relentlessly severe pain made symptomatic relief by alcoholic injection appear advisable. At that time the worst pain was in the back and flanks from about the eighth to the twelfth thoracic segments, and was slightly more severe on the right than on the left. The patient appeared worn and haggard; he had had no sleep for many days, and salicylates and codeine had given no relief.

Since no satisfactory diagnosis had been made, the prospect of abolishing the pain by alcoholic injection seemed very doubtful. It was decided to treat one limited area first. Accordingly, on July 25, paravertebral block of the right seventh to twelfth thoracic and first lumbar nerves was done with 1 per cent procaine followed by 80 per cent alcohol. That night he slept well for the first time in many weeks. The following day he continued to make up lost sleep. There was dulling of sensation to pin-prick over the area supplied by the treated nerves, but his relief seemed out of proportion to the extent of the area anesthetized. On July 27 an embolus lodged in the left femoral artery; embolectomy was unsuccessful and amputation at the mid-thigh was done on August 6. Malignant endocarditis was suspected, but physical examination revealed no sign of it. Twenty-four days after injection he died suddenly, having had no recurrence of the pain in the back and flank. A limited autopsy showed malignant endocarditis, extensive metastatic carcinoma of the liver and lungs, primary in the bile ducts, and pulmonary embolus as the cause of death. The pain of which he was relieved by alcoholic injection was presumably due to an infarct of the kidney or to pressure on the spinal nerves or cord from metastatic carcinoma.

*For Pain in the Pelvis and Lower Extremities:* In the treatment of sciatica, the high acclaim that has been accorded a large number of drugs<sup>9,31</sup> and methods, and the failure of any of these to be adopted by the profession generally, make one suspect that some of the reports may have been written in a spirit of over-enthusiasm. Schlösser, who, in his work with trigeminal neuralgia, originated alcoholic injection of peripheral nerves, recommended the

method in sciatica after using it in 38 cases.<sup>81</sup> Most of his followers, however, abandoned the method because they found that in both their clinical and laboratory work it was frequently followed by paralyses.\* The perineural injections of 10 c.c. of 30 per cent to 50 per cent antipyrin solution on the one hand<sup>32,34,35</sup> and of large amounts of physiological saline solution on the other,<sup>9,31</sup> appear to be worthy of further clinical use. Both preparations have been used with apparent success in many hundreds of cases by their proponents.

The epidural injection of various solutions into the sacral canal through the sacral hiatus has been used very extensively not only for sciatica but for a large number of other conditions as well, such as lumbago, coccydynia, painful amputation stump, lightning pains of tabes, functional urinary incontinence and undiagnosed pains of the pelvis and lower extremities. The French have tended to favor the use of "serum artificiel,"† and have given most extravagant reports of cures in several thousand cases of most diverse nature.‡ Good results have been more conservatively reported from the use of antipyrin and of quinine urea hydrochloride.<sup>33,37</sup> Feuilleade writes convincingly and very favorably of his results in treating soldiers with sciatica due purely to exposure, by injections of "serum artificiel," cocaine or stovaine, repeated up to eight times at intervals of three to four days. Rosenheck and Finkelstein, using procaine solution and physiological saline solution,<sup>75</sup> found their results very inferior to those of Feuilleade, and attributed their relative failure to the fact that most of their cases were secondary to orthopedic conditions rather than of the so-called idiopathic type.<sup>76,77</sup> In this country and in Canada the repeated epidural injections of procaine have been more favorably received than the other methods previously mentioned.<sup>58,93,94</sup> By this means and by

\* See Ref. 5, 15, 22, 23, 30, 61.

† Physiological saline solution.

‡ See Ref. 11, 12, 21, 29, 83.

the removal of foci of infection, Ott of the Mayo Clinic treated a group of patients whose sciatica was not secondary to other disease; he restored to their work or permanently cured 66 per cent of them.<sup>67,68</sup> Before treatment 79 per cent of the group were either bedridden or required a crutch or cane. The method continues to be in such favor there that it is still used regularly as an accepted form of treatment.<sup>14</sup>

CASE IV. *Painful carcinoma of urethra and bladder; alcoholic sacral block; relief.* Male, aged forty-two, came to the Clinic late in June, 1927, complaining of melena, rectal pain and tenesmus. In July a colostomy was made and the rectum excised for adenocarcinoma of Grade 3 malignancy. In December, 1928, carcinoma of the prostatic urethra was found. Suprapubic cystostomy and x-ray therapy failed to give relief. For months his sleep was interrupted every few minutes by urethral burning and a feeling of urgency. Intense pain was referred to the penis and perineum, especially in the former location of the anus. He repeatedly threatened suicide and begged piteously for anything that might lessen his suffering. It was therefore decided to run the risks incident to blocking the sacral nerves with alcohol. The patient was willing to face the possibility of paresis or paralysis of the lower extremities; the sphincters needed no consideration on account of the colostomy and cystostomy. A preliminary trial sacral anesthesia with procaine gave complete relief for six hours, and freedom from urethral pain for twenty-four hours. With this promise of success, alcoholic block was undertaken a few days later, on January 4, 1929. It was hoped that caudal injection might be omitted and trans-sacral injection used alone, in order to prevent upward diffusion of the alcohol. This procedure, however, could not be followed, as the patient would not tolerate the insertion of needles into the foramina until some degree of analgesia had been produced. Therefore the sacral canal was first injected with 20 c.c. of 1 per cent procaine solution, and each of the second, third, fourth and fifth foramina with 5, 3, 2, and 2 c.c. respectively. In order to minimize its upward diffusion, only 8 c.c. of 80 per cent alcohol was injected into the sacral canal, and that very slowly, the point of the

needle being withdrawn meanwhile from the level of the second pair of foramina to that of the fifth. For the second, third, fourth and fifth pairs of foramina, 8, 5, 4, and 3 c.c. were used respectively. Although a half hour had been allowed to elapse between the injections of procaine and of alcohol, there was moderately severe pain referred to the testicles with the alcoholic injection of the second sacral nerves and to the bladder with the third pair. The total amounts used were 44 c.c. of 1 per cent procaine solution and 48 c.c. of 80 per cent alcohol. Anesthesia of the perineum, scrotum and most of the penis persisted for at least nine months. Immediately after injection there was paralysis of the flexors of the right knee and of all of the muscles of the right foot. Half an hour later, power was beginning to return to the knee flexors. Six hours after injection both extremities, including the feet, moved freely but without strength. The following day there was fair strength in both extremities, but no power of external rotation of the right hip. From the fifth day on, the patient walked without a cane, though the gait was waddling and weakness persisted in the abductors and external rotators of the right thigh and in the extensors of the right toes.

For several months after injection there was no return of the severe pain referred to the bladder, penis and perineum, except that on January 12 and 13 there was transient pain in the penis. However, nine months after the first injection of alcohol new areas of agonizing pain developed in the suprapubic region and below the right inguinal ligament. Paravertebral block of the right first and second lumbar nerves with procaine and alcohol resulted in complete transient relief followed by return of the pain in somewhat less severe form, although anesthesia to pin-prick persisted. This pain appears to have been due to an abscess which worked its way to the surface in the anterior aspect of the thigh, where it was later drained. The mental disintegration which occurred before death and the probable spreading of the carcinoma to unanesthetized areas made it impossible to judge whether relief from the first alcoholic block persisted after nine months.

I have found no report in the literature of a previous attempt to produce sacral block with alcohol. However, since this patient was treated, it has come to my

attention that Labat has been using this procedure with caution for a number of years, and has obtained more or less encouraging results in the treatment of various pelvic conditions and of sciatica.<sup>41</sup> In order to avoid paralysis of the sphincters, he suggests starting treatments with procaine dissolved in a 10 per cent solution of alcohol, and increasing the concentration of alcohol until motor function is slightly interfered with.

*Diagnostic Use of Paravertebral Anesthesia:* In Germany considerable use has been made of paravertebral anesthesia as an aid in differential diagnosis as well as in therapy.\* Since biliary colic is relieved by blocking the right ninth and tenth thoracic nerves, renal colic by blocking the twelfth thoracic and first lumbar, gastric pain by blocking the right and left sixth to eighth thoracic, and that of appendicitis by blocking the first and second lumbar, Læwen and his followers found the method useful in distinguishing between these diseases, as well as between appendicitis and pneumonia. Moreover, the muscular relaxation which follows the injection occasionally permits the palpation of tumors otherwise undiscovered. If, as may happen in appendicitis or cholelithiasis, the disease process has spread to surrounding tissues, the paravertebral injection will not bring relief and the diagnosis will remain in doubt. Furthermore, the segmental proximity of the appendix and the kidney makes the method useless in distinguishing between diseases of these two organs. With these exceptions, the evidence afforded by the application of the method appears to have been of definite value in the hands of these authors.

#### SPINAL ANESTHESIA

*In Ileus:* Inasmuch as spinal is one specialized form of regional anesthesia, its therapeutic powers may be considered here. The value of spinal anesthesia in the relief of postoperative paralytic ileus

appears to be quite generally conceded. The few adverse criticisms that have appeared have dealt mainly with its use in cases of mechanical obstruction\* or of poor operative risk,<sup>18</sup> or have been based on an unaccepted theory of the pathological physiology involved.<sup>92</sup> The pioneer in this field, Wagner, handled the subject in such a masterly manner in his first reports<sup>95,96</sup> that other writers have not been able to add much of importance. Not only did he report and advise its use in postoperative paralytic ileus, but he also warned against its use in the presence of mechanical obstruction or far-advanced disease, and even brought out the theory of the neurological mechanism involved in recovery, which waited four years for laboratory proof.<sup>†16,17,59</sup> Mayer followed close on Wagner's heels, advising the use of spinal anesthesia for the release of spastic obstruction as well as in paralytic ileus.<sup>62</sup> Mayer's simple statement: "Naturally the method is worthless for mechanical ileus," stands out in marked contrast to the turbulent boiling of the French press four years later‡ on various phases of its use, after the subject had been introduced to that country by Asteriades.<sup>2</sup> After Duval had been accused of concealing the failures in his publications, he brought out an excellent and valuable analysis of 400 collected cases, and drew from them the same conclusions which Wagner had reached five years earlier. The reports which have appeared from various countries since that time indicate that the method is gaining general favor.§ The almost universally favorable nature of these reports is difficult to understand in the face of the grave risk for spinal anesthesia which a large portion of these patients present, because of their dehydration, acute malnutrition, and respiratory

\* See Ref. 18, 28, 45, 46.

† Priority of laboratory proof appears to belong to Domenech, who reported the results of his work to the Society of Biology of Barcelona on June 11, 1926. The report of Markowitz and Campbell was published one year later.

‡ See Ref. 1, 45, 46, 60, 92.

§ See Ref. 27, 38, 49, 85, 101.

\* See Ref. 8, 24, 42, 43, 52, 54.

embarrassment from abdominal distension. One group of recent writers in this country prefer splanchnic anesthesia as being fully as effective and considerably safer.<sup>65,66</sup> Attention should be drawn to the facts that if spinal anesthesia is used it may not prove effective unless it reaches to the sixth thoracic segment<sup>16</sup> and that with either form of anesthesia the peristalsis-inducing effect may fail to appear in case of the concomitant use of chloroform, ether, atropine,<sup>16,17</sup> epinephrine or ephedrine.<sup>66</sup> Presumably scopolamine would have a similar deleterious effect.

*In Labor:* In obstetrics Balard and Mahon of France have found spinal anesthesia very helpful in overcoming certain types of dystocia.<sup>3,4</sup> They find that it abolishes any pathological as well as the normal tone of the cervix, which then becomes flaccid and dilates with great ease and rapidity either manually or spontaneously; the contractions of the body of the uterus become more vigorous, and the perineum becomes completely relaxed. They report easy, rapid deliveries following its use in cases of contraction ring, edema of the cervix, prolapse of the uterus with cervical edema, and failure of the cervix to dilate. In difficult breech presentations, where the fetal heart has become irregular, they feel that it frequently saves the baby's life. They believe it acts by producing a physiological section of the posterior roots of the lumbar and sacral nerves. They advise its use in functional rigidity of the cervix and in the presence of any indication for the rapid termination of labor for the sake of the health of mother or child. Its effect is prompt as contrasted to that of morphine, and it does not produce the severe injuries that forcible dilatation or extensive incision produce. They have encountered no untoward results, and have found that the cervix at the time of the patient's discharge from the hospital appears the same as after normal labor.

*In Eclampsia:* In connection with the consideration of dystocia it is interesting

to note that Paramore of England, working on the theory that eclampsia is caused by compression of the liver and kidneys, and that relaxation of the abdominal wall might relieve this pressure, induced spinal anesthesia in 1 case of fully developed eclampsia, and was rewarded with the patient's prompt recovery.<sup>69,70</sup>

*In Tetanus:* In the convulsions of tetanus, various forms of local and regional anesthesia with procaine have been used as therapeutic measures much more extensively than in eclampsia.<sup>57,99</sup> Spectacular relief of lockjaw follows the infiltration of the masseter, temporal and pterygoid muscles, with the result that soft and liquid food can be ingested if there is no spasm of the muscles of deglutition. The danger of precipitating general convulsions by the needle-prick may be minimized by the preliminary administration of chloral hydrate. Mandl reports 6 cases of full-fledged tetanus treated by the injection of procaine into the sacral canal, and 4 cases treated by spinal anesthesia. In every case generalized convulsions ceased for a few hours, local spasm of the muscles of the lower extremities and of the abdomen were controlled, and the patients welcomed the treatment. In some the relief was lasting and initiated convalescence.

#### NEUROLOGICAL MECHANISM OF THERAPEUTIC EFFECTS

If we consider the neurological mechanism involved in these therapeutic uses of regional anesthesia, there will be explained some interesting paradoxes, such as the ability of spinal anesthesia to increase intestinal activity and simultaneously paralyze the abdominal wall, and the effect of subcutaneous injections of the anterior abdominal wall in relieving pain that arises elsewhere, namely in an underlying viscus.

Paralytic intestinal ileus is conceded to be the result of reflex inhibition of intestinal peristalsis and tone; spinal anesthesia, by producing physiological section of the splanchnic nerves, breaks the reflex



arc, removes the inhibitory influence\* and allows the plexus of Auerbach and the parasympathetic nerves to have free play

from which the impulse started, but to the skin area supplied by these cutaneous sensory nerves. This is the phenomenon of

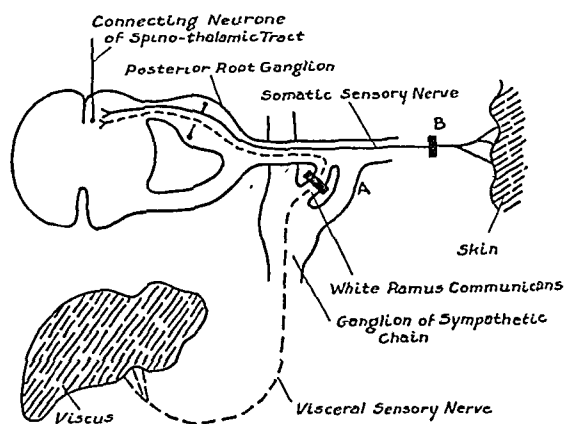


FIG. 2. Mechanism of referred pain—MacKenzie theory. Afferent impulses pass through visceral sensory neurone by way of white ramus communicans to connecting neurone of spinothalamic tract. Interpreted by higher centers as coming from somatic sensory nerve. May be interrupted by producing a block at A. This theory does not explain how a block produced at B relieves pain. (From LeMaire.)

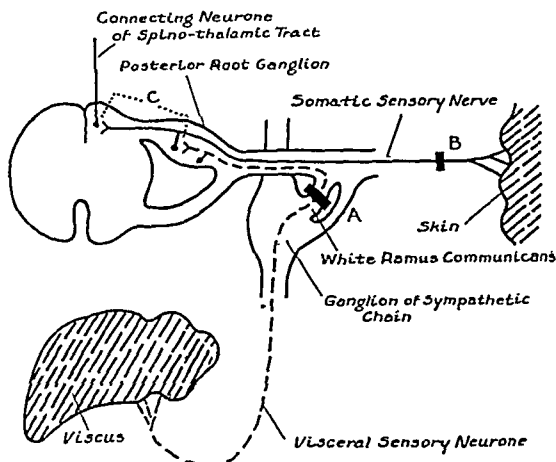


FIG. 3. Mechanism of referred pain—Edinger-LeMaire theory. Portion (c) of somatic sensory nerve interpolated in course of afferent visceral impulses. LeMaire assumes that a block produced at B affects proximal as well as distal portion of somatic sensory nerve, and thereby stops transmission of afferent visceral impulses at c. (From LeMaire.)

in producing motility. Ether or chloroform anesthesia or atropine will in turn render these nerves also ineffective, and permit ileus to continue even in the presence of spinal anesthesia.

The therapeutic action of paravertebral anesthesia and of field block involves the mechanism of referred pain. According to MacKenzie (Fig. 2) the afferent autonomic fiber† transmits its impulse, by a synapse in the cord, to the connecting neurone which transmits it to the higher centers by way of the spinothalamic tract. This same connecting neurone has synaptic connection with cutaneous sensory nerves as well. The higher centers, being accustomed to receiving through this neurone sensory impulses which arise in the skin, interpret as coming from the skin all impulses which arrive over the same neurone; i.e., they project the stimulus not to the organ

\* See Ref. 16, 17, 27, 59, 62, 95, 96, etc.

† Some deny the existence of afferent autonomic nerves, maintaining that all nerves which transmit sensory impulses whether somatic or visceral, are spinal nerves.

referred pain, sometimes called the viscerosensory reflex. Other authors in addition recognize the reference of stimuli to the organs themselves, a special visceral sensation, such as is perceived with extrasystoles and other forms of palpitation. Paravertebral block is believed to produce a sectioning of the ramus communicans through which the afferent autonomic fiber runs.\* If done with procaine, it is a so-called physiological section; if with alcohol, it becomes an anatomical section.

This, however, does not explain the relief of visceral pain which follows local subcutaneous infiltration with procaine. In this circumstance the procaine does not directly affect either of the neurones through which MacKenzie would have the impulse pass. LeMaire, in his very interesting discussion of the problem,<sup>47, 48</sup> therefore adheres to Edinger's theory that the visceral afferent fiber does not carry the pain impulse into the cord, there to transmit it to the connecting neurone,

\* See Ref. 8, 44, 72, 87, 90, 98, etc.

but rather that in the posterior root ganglion it transmits the impulse to the cutaneous or somatic sensory neurone, through which it is then transmitted to the connecting neurone in the cord (Fig. 3). The portion of the somatic sensory neurone that lies in the posterior root is thereby made to form one link in the transmission of the impulse from the viscus to the higher nervous centers. Therefore LeMaire has to assume that the procaine injection of the distal portion of the somatic sensory neurone must affect the function of its entire extent, thereby breaking the sensory pathway. Such a mechanism would help to explain the relief of visceral pain obtained not only by the subcutaneous injection of procaine, but also by the application of heat or cold and various forms of stupes and plasters to the skin. This theoretical functional alteration of the entire extent of the neurone seems parallel to the structural alterations found after alcoholic or other injury to a nerve trunk. Such injury results not only in the disappearance of the distal portion of the myelin sheath and axones (Wallerian degeneration),<sup>22,64</sup> but also in degenerative changes ("axonal reaction") in many of the nerve cells in the posterior root ganglion.<sup>10,61</sup>

Since alcoholic nerve-block may occasionally bring such welcome relief from pain, especially from that of malignant disease, it is a measure that the therapist should bear in mind and be ready to call into use. Moreover, its frequent success in such neurovascular disorders as reflex anuria and angina pectoris suggest that its use may possibly be extended to include the treatment of such diseases as intermittent claudication, erythromelalgia and Raynaud's disease,<sup>91</sup> sharing this field with sympathectomy.

#### DISCUSSION

DR. HENRY S. RUTH: It may be realized by consistent reasoning that any anesthetist (my antagonistic nature makes me glory in repeating that word anesthetist, because it is so belittled in some medical circles and yet some of us have

so much faith in it) well, to proceed, it is logical to realize that an anesthetist, who scientifically practices regional anesthesia, as it has recently been elevated by our own President, Lundy and others, has had the necessary experience to efficiently practice alcoholic nerve-block. Any factor which will allow a further service of anesthesia will immediately and automatically raise our specialty to a higher plane.

I should like to suggest a procedure which may save some of you from an embarrassing suit for mal-practice, of which several cases are on record, although fortunately none of my own. It applies largely to alcoholic nerve-block of the fifth cranial nerve. After injection has been completed and as the needle is being withdrawn, inject just a small quantity of normal saline solution. This precludes the possibility of the alcohol which remains in the lumen of the needle from being distributed over the course of the needle as it is withdrawn and anesthetizing close-lying fibers of the seventh cranial nerve, with resulting partial facial paralysis.

Many times after repeated injections of the fifth cranial nerve, 80 per cent alcohol is not effective, whereas 95 per cent alcohol may be. To cite a case, Mr. F, seventy-eight years old, had, according to his own statement, 18 injections of the fifth cranial nerve over a period of many years, just how many he could not recall. He was referred to me and I injected 1 c.c. of 2 per cent novocaine and 2 c.c. of 80 per cent alcohol in each of the second and third branches of the fifth. No relief resulted. After a period of ten days, I injected 1 c.c. of 2 per cent novocaine and 2 c.c. of 95 per cent alcohol in both branches, after which he had complete freedom from pain and no unpleasant complications. I am certain I made an intraneural injection in both cases.

Dr. Woodbridge has not mentioned the technic of Yeomans for coccydynia, which I have found to be useful and simple. With the index finger in the rectum, the point of maximum tenderness is determined by pressure with the thumb externally. With a small needle, puncture is made in the midline and directed immediately toward this spot; when the spot is reached, the patient usually exclaims when 10 to 20 minims of alcohol are injected.

Yeomans claims only 14 per cent failure with this procedure.

Varying results have been reported with

alcohol nerve-block of the fifth cranial associated with cervical block for inoperable carcinoma. I believe that, where the entire malignant mass is supplied by these nerve fibers, failure results from improper technic only. Strict attention to detail in this type of anesthesia cannot be over-emphasized. As to spinal anesthesia for paralytic ileus, I can add nothing, except to recommend it in the true paralytic type where the risk is not of an extreme grade.

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## UTERINE TUMORS\*

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I NEVER hear the statement in medical parlance that "each case is a rule unto itself" without feeling that this teaching is a two-edged sword and in no condition to my knowledge will the double-edged sword more often take its toll than in uterine pathology.

The profession should have learned to its sorrow that the classification of the treatment of an acute lesion such as appendicitis into operative and non-operative hours, has increased the death rate in America during the past fifteen years 30 per cent, yet this is an attempt to teach that each case is "a rule unto itself," from the standpoint of surgical management.

I believe medical statesmanship is much needed in dealing with any acute or destructive lesion in which signs and symptoms are not proportionate to the severity of the lurking pathological condition.

In considering a remedy for any lesion, first we must reckon with cost, namely, mortality, morbidity, postoperative history, whether the organ can be disposed of, whether the remedy is accessible, whether it can be applied by a good number of the profession with facility and how favorable are the surroundings in which the patient is placed.

In order to simplify remedy and standardize treatment, these factors which concern mortality, morbidity, etc. then become the concern of the medical or surgical statesman whose counsel would be that a certain remedy meets most conditions. This is most true in dealing with uterine pathology.

In discussing the common lesions of the uterus we are concerned with the age of the uterus and its value to the particular

patient: should the uterus be preserved even at certain risks, should conservative treatment be tried, what are the dangers of conservative treatment and what are those of radical measures. No wonder the student of the condition is afflicted with the burden of uncertainty, a precarious state of mind to deal with that which is often a rapidly fatal lesion. This is exactly the teaching which is given the student of this day and we feel it must not stand.

There is precisely such a dearth of attempts to arrive at the proper diagnosis of those conditions which may produce a bleeding uterus. Indeed, in a great number of patients who come to the hospital for a uterine hemorrhage, no attempt at diagnosis has been made.

Patients having threatened abortion or abortion, ectopic pregnancy, fibroid tumors or fibrosis of the uterus, malignancy, hyperplastic endometritis, excessive uterine hemorrhage from tubal and ovarian infection or ovarian tumors, etc., often come to the institution with the simple diagnosis of uterine hemorrhage.

All physicians have entrée to the clinical history of the patient and I am sure that a very reliable diagnosis may be made from the clinical history in over 90 per cent of the patients who are being exsanguinated from the bleeding uterus.

From what comes the lack of interest in the etiology of these preventable lesions? It cannot be ignorance. Is it the lack of habits of industry, has the examining hand been placed upon the patient, is the general profession too dependent upon the nearest consultant? We may wonder but the real crime is the loss of time and action.

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In the evening of our thoughts we may speculate upon metaphysical propositions but the gangrenous appendix and malignant uterus must be dealt with in no speculative manner.

Never was the uterus so much on trial for its surgical pathology as at the present day.

Radium and x-ray have much divided the opinions of men during the present era in the treatment of uterine pathology.

The first question which comes up for discussion when dealing with the pathological uterus where malignancy or any tumor is suspected, is: what is the mortality of the remedy? This is more often the determining factor than morbidity, postoperative complications, etc.

The very high death rate of the Wertheim hysterectomy makes this procedure unpopular and scores for radium or x-ray.

The ordinary panhysterectomy has a higher mortality than the supervaginal removal of the uterus which is not to be thought of in dealing with the malignant uterus, so again the more conservative methods are advocated.

In over 90 per cent of the malignant uteri the cervix is the site of the growth; therefore, the abdominal route of removing the uterus suffers this embarrassment, so surgery has been penalized and radium and x-ray have become popular in the treatment of uterine growth.

The mortality from panhysterectomy in the large clinics for malignant and benign tumors will vary from 5 to 20 per cent, supervaginal amputations may be done with a smaller death rate but is not considered in dealing with malignant growths.

For over fifty years vaginal hysterectomy clamp method has been done in the Joseph Price Hospital for all malignant conditions of the uterus where size of growth permitted removal by vaginal route and for over thirty years in this institution all uterine tumors, size permitting, when not complicated by tubal and ovarian infection, have been removed by vaginal hysterectomy clamp method.

The mortality has ranged from one-fifth to one-third of 1 per cent, so we are permitted to say that vaginal hysterectomy clamp method has the lowest mortality and the best postoperative history of any major operation with which we have had experience.

Were it not for the clamps we would not do vaginal hysterectomy.

The uterus may be removed in 90 per cent of the cases by the clamps in from three to five minutes and it permits very much more extensive removal of tissue than can be done by the ligature method; thus its virtue in malignancy.

The percentage of operability by clamp method is double that of ligature method in dealing with either malignant or benign tumors.

The rapid time in which the operation can be done and the avoidance of infection because the procedure is an outside operation reduce all untoward symptoms and calamities to a minimum.

I have never seen a sudden death due to embolus or heart collapse as is most often seen in superpubic hysterectomy. Indeed, the rate of sudden deaths following superpubic hysterectomy due to embolus or cardiac dilatation is greater than from all causes following vaginal hysterectomy.

I have seen but one shocked patient following vaginal hysterectomy; I have never seen a postoperative bowel obstruction follow vaginal hysterectomy nor a postoperative pneumonia nor a death due to suppression of the urine.

There is no trauma to the abdominal wall in vaginal hysterectomy, and all factors which contribute to shock and trauma from traction on the parietal peritoneum are avoided.

The very low death rate from vaginal hysterectomy clamp method challenges all abdominal operators and makes many of the shortcomings of the abdominal route most conspicuous.

Those operators who have not had experience with vaginal hysterectomy clamp method are in no position to discuss

the relative merits of the operative treatment of uterine tumors compared with that from the application of x-ray or radium.

Any operator who removes the uterus as a panhysterectomy will have from fifteen to twenty times the mortality than will occur in vaginal hysterectomy.

The patient who weighs from 170 to 225 lb. will show a frightful mortality when operated on from above as compared with the vaginal route.

I am not attempting to denounce radium or x-ray treatment for malignancy in general. Irradiation in locations such as the mouth, skin and superficial areas has been a great blessing, but for permanent results with deeper malignancy the results are not consistently good and the advocates of irradiation must make frank expression of its limits of usefulness.

In regard to irradiation of the malignant cervix where the best results are said to be obtained in dealing with the malignant uterus, the histopathology of the organ must be considered. In my opinion we cannot say that malignancy of the cervix is particularly amenable to irradiation especially on account of the cellular type of the malignancy but is it not due to the length of time that cervical malignancy remains a superficial growth; and it remains a superficial growth on account of the fact that the mucous membrane of the portiovaginalis has no glands, the vaginal cervix being lined with stratified epithelium in which there are no glands penetrating the deeper stroma and thus extending the malignancy to structures beyond.

Glands are not found on this area of the cervix unless they have been carried down from above by prolonged erosion.

Lacerations of the cervix permit ingrowth of epithelial cells and thus squamous cells become displaced and are found deep in the cervical tissue and this ingrowth of malignant tissue is not as amenable to irradiation as the more superficial growth.

As operators, we know that the great cauliflower-like growth of the cervix often

has not extended deeply into the cervical tissues and therefore is more susceptible to treatment than the penetrating ingrowth of malignant tissue which is less conspicuous as a malignant lesion but more deadly.

There is no point of location in the anatomy where cause and effect in their relation to malignancy are so definitely depicted as is seen in the lower third of the cervix; here we have transition of epithelial cells from columnar to squamous type, we have the most traumatized area of the body in the child-bearing patient and here are cells which were bathed by a sterile uterine alkaline medium, thrust or misplaced by injury into an infected vaginal irritating acid medium, and there are also misplaced cells incident to injury which have been cut off from their normal nutritional surroundings. These injured and misplaced cells are constantly being bathed by an irritating discharge incident to the erosion, inflammation and infection.

So all these factors are important elements in predisposing this cervical area to malignancy which is forcibly shown from the fact that over 90 per cent of malignancies of the uterus occur in this area.

It is not so much my intention to go into the histopathology of the subject of uterine growth as it is my object to advise a more definite remedy which may be put in the hands of the ordinary careful operator.

A week before the death of Joseph Price, I asked him what would be his Swan Song (meaning his last message to the profession) and he said, without a second's hesitation, "The profession must be taught to do vaginal hysterectomy clamp method for all tumors of the uterus which will permit vaginal removal; it is the solution of malignancy of the uterus and the profession must be taught to do more radical work in the peritonitic abdomen." At this hour, eighteen years after his death, were I asked the same question my answer would be the same as that of my distinguished teacher.

When one takes into consideration that

Price undoubtedly had the largest experience of any operator in America in vaginal hysterectomy and probably also with the peritonitic abdomen, his message should not remain unheard; and I would like to add that it never was more needed than at the present hour.

In summing up, my points in argument would be:

1. Vaginal hysterectomy clamp method has the lowest death rate and the best postoperative history of any operation of my experience.

2. It is accessible to all ordinarily competent operators; radium and x-ray are not.

3. The operation from below is safe from sudden surgical tragedies, such as are often seen in the superpubic route.

4. In the fleshy patient the operation may be done with as much ease as on the spare woman and with a death rate of one-twentieth that of panhysterectomy.

5. It is a very much more thorough operation when done with clamp than with ligatures, as all tissues within the bite of the clamp sluff away and malignant and potentially malignant tissues are thus cast off.

6. The operability of vaginal hysterectomy clamp method is over twice that of the ligature method.

7. As over 90 per cent of uterine malignancies occur in the cervical end of the uterus, the vaginal route is the more accessible and malignant tissue is not drawn up into the abdominal cavity as is the case in the abdominal route.

It has been stated by Wertheim, the father of the most complete abdominal operation for the malignant uterus, that if the abdominal glands are truly malignant the malignancy will return in all probability, so the vaginal route suffers little from the standpoint of not removing the abdominal glands.

The very low mortality of vaginal hysterectomy clamp method and its almost total absence of postoperative complication place it as more than a worthy

competitor with either x-ray or radium: indeed, I have seen a great number of complications following irradiation.

I have advised a great number of patients with simple fibroid tumors of the uterus, to have a hysterectomy performed; if they have refused operation and have been treated by irradiation, I have had these same patients return to me from four to six years after such treatment with diffuse malignancy.

Fundal malignancy is an easy victory for vaginal hysterectomy clamp method and certainly should never be considered as amenable to irradiation; too much emphasis cannot be laid here.

In fundal malignancy biopsies are most uncertain and such absence of certainty should never be met with irradiation but by removal of the organ.

In treating cervical malignancy with irradiation can we afford to take for granted the well-being of the upper two-thirds of the uterus. I am sure we must not and the removal of the uterus will save many lives.

The large percentage of cases in which the condition suggests removal of the uterus occurs in nearly all cases where the organ has finished its function and therefore may be removed without untoward results.

Any attempt to classify malignancy of the cervix into the three groups representing squamous cell, transitional cell or embryonal cell type and then applying irradiation to a particular type cell, brings forth a confusion which cannot be tolerated in dealing with malignancy.

When one compares the elements of doubt both from a pathological and a remedial standpoint which are factors in the treatment of uterine tumors with radium and x-ray with the element of certainty which characterizes vaginal hysterectomy clamp method, there can be little hesitation as to choice.

From a psychological standpoint the removal of the uterus for any kind of growth gives comfort of a substantial

nature, whereas the treatment with irradiation or other conservative means leaves the future full of uncertainty and apprehension.

The very low death rate following vaginal hysterectomy is a strong plea for earlier surgery, just as an acute surgical death is a deterrent for early surgery. The acute surgical death always influences a community against early surgery.

Statistics obtained from the treatment of uterine tumors by the available remedies are most unreliable, just as they are in the peritonitic abdomen. One operator would claim that a certain malignant lesion of the uterus was still operable or amenable to irradiation, while another that the same condition was past human assistance.

We are constantly seeing patients who have been refused surgical treatment on account of being too late whom we consider very good risks for vaginal hysterectomy clamp method; and we are also seeing a good number of patients who have been treated with irradiation six months or more after further like treatment had been abandoned as useless and yet we consider these patients subjects for vaginal hysterectomy clamp method; that is what I mean by saying that statistics are very unsatisfactory.

In an organ where the actual cautery can be used extensively such as in malignancy of the cervix, it becomes a worthy competitor of irradiation.

All of our malignant cases are extensively cauterized before vaginal hysterectomy is begun, the tissues being charred down to firm structures and then the entire upper third of the vagina if necessary may be removed by the clamp method. It is my opinion based upon a large experience that if the operating profession will take up vaginal hysterectomy clamp method, malignancy of the uterus can be reduced within a short number of years to almost vanishing point.

This brings out the message of my paper which is, that we have a surgical procedure in vaginal hysterectomy clamp method that has the very highest percentage of operability in malignancy with the very lowest mortality, which virtues will move all such cases toward an earlier operative hour; no several means of treatment will do this.

The technic of vaginal hysterectomy clamp method is fully illustrated in a monograph entitled *Practical Surgery of the Joseph Price Hospital*.





# TONSILLECTOMY BY DIATHERMY

## ELECTROCOAGULATION METHOD\*

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MY persistence in submitting this, the fourth paper within the past four years on this subject, is due solely to the fact that I want to so impress its importance upon the profession that our internists and laryngologists will give it a thorough trial; rather this, than to have the laity force it upon the profession. I believe we are gaining ground, as I have a file filled with communications of inquiry from Boston to Seattle, and from Canada to Texas. Further, patients come from New York, Chicago, New Jersey, Philadelphia, Canada, Ohio, Illinois, West Virginia, and Tennessee, everyone of whom we believe is an enthusiastic propagandist. For these reasons I am persuaded that there is a growing interest in this subject.

What is the cause of our slowness to take up that which appears to be new? I think an editorial<sup>1</sup> rather apropos: The editor quotes from Walter L. Lippman's "Men of Destiny" as follows: "Although we are all endowed with eyes, few of us see very well. We see what we are accustomed to see and what we are told to see. When we find a pattern which works well, in that it allows us to feel that we have made a large area of reality our own, we are grateful, and we use that pattern until it is thread-bare." The editor comments:

And who is better supplied with a pattern by which to shape his beliefs and his life than the physician, and who offers more determined resistance to the new discovery and the new method unless it comes well introduced by authority? Yet, who should be better equipped to realize that authority no longer holds the reins of civilization? Who should be more responsive to new ideas, for who deals with an art and a science less complete, the outermost boundaries of which have not yet been even sighted? Why, having attained his pro-

fessional majority, does he so often cease to grow?

I, for one, believe this to be only too true.

We affirm that tonsillectomy by diathermy is the only new method that has been presented in tonsil surgery within the past two hundred years. In proof thereof we submit that in the latter part of the eighteenth century, Moscati, an Italian, tried scissor dissection, but criticisms from the older and more conservative surgeons kept others from giving it a trial. Earlier in the same century, the wire ligature became very popular and was universally used. This was a crude antecedent of our present day snare operation. Celsus, born in 25 B.C., gives one of the first accounts of tonsillectomy, being criticized severely because he advocated the removal of tonsils with a knife. Fabricius condemned the knife because of the danger of hemorrhage. Paulus Egenita recommended the use of a hook and bistoury, but for the same reason of hemorrhage it was discarded. The actual cautery attempted to solve the problem met with but little favor. Following this, slow acid caustics came into vogue and were used for several centuries. The ligature method was employed in America until about 1830. This consisted of encircling the tonsil with a silver wire which was drawn tight and left in place to be tightened daily until after four or five days, the tonsil was severed. This procedure was so extremely painful that it fell into disuse. As late as 1828 Dr. Alexander E. Hosack of New York returned from France, where he had seen tonsillectomy performed by knife dissection. The operation was quickly done, and with a small amount of hemorrhage. He performed

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four of these operations, publishing his comments under the title "Remarks on the Various Modes Usually Adopted for the Removal of Tonsils."<sup>2</sup> Dr. Physick of New York condemned the method as very dangerous. So we submit that, aside from more perfect instrumentation, improvement in technic and asepsis, diathermy is the only method which would even have satisfied the throat specialist as far back as two thousand years.

Now, why do we wish to supplant the present surgical tonsillectomy which has received such universal approval, and which has been used for so many years? I believe the entire profession recognizes that there is no operation which has so many serious complications when they do happen as does the surgical tonsillectomy. It is indeed a major operation, with such complications as hemorrhage, primary and secondary, shock, pneumonia, lung abscess, often with gangrene of the lungs, and attending dangers always present from either general or local anesthetic, secondary infections, trauma to soft tissues, accompanied often by edema, sloughing, the later disagreeable effects from scar tissue, embolism, etc.; these are all too well-known to necessitate a detailed discussion here.

Harlow Brooks of New York is quoted as saying that he will not advise any of his patients over forty years of age to submit to tonsillectomy. Judson DeLand of Philadelphia in a paper read before the American Academy of Ophthalmology and Otolaryngology at Montreal, Canada, says that many physicians and laryngologists fail to recognize the etiological relationship of the removal of infected tonsils to pneumonia and pulmonary abscess, and that they occur more frequently than is generally believed, and may occur one or two weeks after the operation, and in such cases the causal relation to tonsillectomy is frequently overlooked. He adds that a technic should be devised so that the duration of the operation and the anesthesia is reduced to a mini-

mum (lessening the shock and risk of absorption or aspiration of pathogenic microorganisms).

Chevalier Jackson, of Philadelphia, in a paper on the subject of post-tonsillectomic pulmonary abscess,<sup>3</sup> says: Myerson found blood, bronchoscopically, in 26 out of 100 cases of tonsillectomy. As the source of the blood was in the tonsillar field of operation, the inference is justified that the blood carried with it infective agents from the tonsil. Fetterolf placed mortality in cases of post-tonsillectomic pulmonary abscess between 25 and 50 per cent. Wessler found that 80 per cent of post-operative cases of pulmonary abscess in his experience had followed tonsillectomy. Lord found that out of 96 cases of lung abscess 78 were due to operation about the upper respiratory passages, and 49 of these followed tonsillectomy. All of these were performed under general anesthesia. Jackson follows this with a plea for more careful technic in preparation of patients, minimum of anesthetic, elimination of time wasting, the avoidance of trauma, use of low head position, and many other details, showing his great concern in this one serious complication of tonsillectomy. The Mayo Clinic reported in 1924 that 31 per cent of postoperative cases of lung abscess followed tonsillectomy under general anesthesia; but that in 16,000 tonsillectomies under local anesthesia, and in 4000 children under general, they only had 2 cases of lung abscess.

In the Bordeaux Clinic, France, no lung abscess follows tonsillectomy, and it is maintained that this is because they operate only with local anesthesia on adults, and use chloroform for children.

It is my firm conviction that 75 per cent of the dangers attending surgical tonsillectomy in adults would be removed if they were all performed under a local anesthetic, and if any surgeon who is not skillful enough to quickly remove tonsils under local, or whose method is so severe that the patient could not stand the pain, should either change his method or

try to become a more skillful operator. Next to hemorrhage, I consider pneumonia and lung abscess the most serious complications attending surgical tonsillectomy. I feel that there is too great neglect on the part of the surgeon in not following up the after-history of these cases. I know a surgeon who says he has not lost a case following tonsillectomy in twenty years. Yet in fourteen days after he had operated on a young man, the patient died from gangrene of the lung, diagnosed as such by an eminent lung specialist, who placed the responsibility entirely upon the operation. We know that the so-called ether pneumonias are simply pneumonias caused by the aspiration of infected material from the tonsil which is expressed by the manipulations of the surgeon and is taken into the lung during anesthesia.

Another serious complication to which little notice, if any, has been taken, and which may happen one or two years after the surgical removal of the tonsil, is an infection or reinfection of the myocardium caused by the flooding of the blood stream with microorganisms at the time of operation.

Dr. Mayer of New York conducted an inquiry a few years ago asking for a report on the complications and deaths from local anesthetics. This was of decided benefit to the profession, in that it brought to their attention most vividly the dangers from these anesthetics if carelessly administered. I would like to suggest that the editor (who stated some time ago<sup>4</sup> that diathermy of tonsils was not sufficiently proved and was often dangerous) conduct a questionnaire and have a reply from everyone doing surgical tonsillectomy as to the number of serious hemorrhages, pneumonia, lung abscesses and deaths they have had during the past year. I will venture that the results would be most alarming, and that if the public became cognizant of these facts, our surgical tonsillectomy would not hold its place numerically very long, and I believe

the profession would have its eyes opened to this so-called simple operation.

I feel so keenly and profoundly on this subject of the hazards of the surgical procedure, particularly when after five years' experience with tonsillectomy by diathermy, I know that they can all be avoided, and to some extent I feel that this is borne out by the profession itself when you see how difficult it is to get a doctor, and particularly a throat specialist, to submit to this operation. I have removed more tonsils from doctors in the past two years by diathermy than I have in the previous twenty years by the surgical method.

I feel that, as I am asked so frequently what we do about children's tonsils, a word here would not be out of place. Most children from seven years of age and older readily submit to diathermy treatment. I am now treating a child of five years, but after the first two treatments she "got wise to us" and we had to resort to gas and oxygen. I would not attempt any other anesthesia in these cases, as I consider them too dangerous on account of their explosiveness.

I do not believe in the promiscuous wholesale removal of tonsils in children as practiced today. In the first place, as a general rule, children's tonsils, if infected at all, are either on the mucous membrane or in the very superficial part of the tonsil. We usually find *Streptococci viridans* in children's tonsils, whereas we find the *Streptococci hemolyticus* in the adult tonsil. If the child's tonsil is so hypertrophied as to obstruct the throat, we believe in a purposeful tonsillotomy, removing the portion of tonsil extending beyond the anterior pillar, thus leaving a portion of the tonsil to carry on whatever function nature has intended it to perform.

I have in my notes from Prof. Portmann's lectures in Bordeaux, France, his theory of the function of the tonsil. He believes that from the various bacteria that are collected in the tonsil, a vaccine is manufactured which goes into the

circulation of the child and protects it from the toxins which are constantly getting into the bloodstream, thus protecting the child during its development and growth, who when having arrived at puberty, does not need this protection further, and nature has intended then that there should be a progressive atrophy of the tonsil. This atrophy of the tonsil in later years after puberty proves that the function of the tonsil is only during childhood. This I consider about the most logical theory of the function of the tonsil. If this is true, are we not weakening the child's resistance by the removal of the tonsil, except in those cases in which the infection is severe and is causing systemic reactions?

Four years ago in a paper read before the Allegheny County Medical Society of Pittsburgh I made mention of the close relationship existing between the tonsils and the thyroid, and further that we knew the thyroid was intimately connected with the ovaries, testes, and other glands, and asked the question then whether or not the removal of the tonsil could affect the sexual organs. At that time this suggestion caused not a little amusement, particularly among some of our younger surgeons, but I find that E. Bates Block<sup>5</sup> reports that in a patient, a boy eight years of age, who had his adenoids and tonsils removed, the testes (which were normal up to that time) entirely disappeared.

I consider the removal of tonsils in children a very serious problem, and as it has been reported that 33⅓ per cent of all operations performed in our city hospitals today are tonsillectomies, I think it behooves the profession not to treat too lightly the now prevailing opinion that probably all children's tonsils should be removed.

As a further thought, Warthin, an eminent pathologist of Ann Arbor, has been quoted as saying that 60 per cent of all tonsils submitted to him after enucleation, he found to be normal. According to

Kaiser's exhaustive experiment, in which he took 1200 operated cases and 1200 non-operated cases, his report<sup>6</sup> after a period of three years showed that there was very little difference in the physical condition of the two groups. One more suggestion in connection with removal of tonsils and adenoids in children. I am positive that a great number of tubotympanic catarrhal cases occurring in children is due to the fact that the tonsils and adenoids are removed at the same time. This can in a large measure be averted if the adenoids were removed four or five weeks after the tonsil operation. When done at a single sitting, we have three large infected areas which of necessity must extend into the eustachian tube. Thiebault<sup>7</sup> reports from a survey of a large number of school children that 33 per cent had tubotympanic catarrh after the removal of tonsils and adenoids.

Now as to our method of choice (tonsillectomy by diathermy), it is not so new in Europe, where it has been used for at least twenty-five years, but mostly not as a routine procedure, but in selected cases. Doyen, of France, used it twenty years ago. Moure and Portmann of Bordeaux have been using surgical diathermy for fifteen years for many purposes, one of which is the coagulation of the tonsil. I have a report made at the request of the Academy of Medicine in Paris by Portmann of Bordeaux, Bourgeois and Poyet of Paris, and Lamothe of Limoges, for the year of 1924, of some seventy pages, which deals only with otolaryngological diathermy, in which they state diathermy of tonsils is very satisfactory.

We shall not enter into any lengthy discussion as to the physics of diathermy or its different methods of application. There are two kinds of diathermy, medical and surgical, both derived from high-frequency current discovered by Nagelschmidt. Diathermy was named by D'Arsonval who experimenting with Nagelschmidt's coils, found a combination that would make heat pass through a body;

hence, the name diathermy. The only difference between medical and surgical diathermy is the difference in the degree of heat registered. The so-called radio knife, which should be more properly called diathermy knife and the needles used in the coagulation carry the D'Arsonval current, which is very high in amperage and low in voltage. With this current there is extremely rapid action. Some who are advocating the dessication of tonsils use the Oudin or cold current, which is very low in heat and extremely high in voltage. I shall not discuss the dessication method, but I would as soon risk the surgical removal of my own tonsils as to have them dessicated. D'Arsonval says that we are but at the dawn of the use of high frequency in surgery.

Howard Kelly<sup>8</sup> says:

In spite of an evident slowly growing appreciation of the value of electro-surgery, the extensive application of this new principle still remains limited to the few more or less specializing in this field. My present plea is for its wider adoption as indispensable in our daily practice as general surgeons, in all our hospitals, and above all in our teaching centers, that our young men may catch the inspiration of these radically new methods and carry them on to perfection. The difficulties are those of all new ventures; as established, successful general surgeons naturally grow set in their ways and look askance at radically new principles. The notion is also curiously current that electro-surgery is but another, perhaps somewhat more convenient and refined way of using the ancient hot iron and therefore, negligible to that extent. An added objection of the *prima facies* sort is that it calls for switchings and sundry manipulations which are sources of delays and inconveniences. Further discouragement follows the discovery that it is after all not quite so easy of effective application as anticipated. Noting these and other objections and making my most conciliatory bow to the objectors, I still insist that our younger men, with pliable brains and flexible fingers, should be given every chance to take the matter in hand and judge for themselves, for I have a supreme confidence that once turned into these inviting new

channels, they will develop a refined and efficient surgical technic which will astound the next generation and help to mark a new era. Let me here stake any reputation I may have for prophetic vision and let the future decide.

Harvey Cushing of Boston is opening up a wide field for electro-surgery in brain and neural surgery, and Walter E. Dandy of Johns Hopkins is advancing on similar lines. It takes but little imagination to envisage the numerous applications possible here.

Kolisher and many others among leading urologists have for years been using diathermy in the coagulation of papillomas of the bladder, which they claim is so superior to the old method with the knife, because with the coagulation method there is no return of a papillomatous condition. If the general surgeon, the gynecologist, the brain surgeon and the urologist speak in such glowing terms of the great usefulness of diathermy, and put it in a class with the knife, radium and x-ray, is it not high time for the laryngologist to recognize the fact that this powerful agent will remove easily, quickly and safely, the small mass of lymph tissue located in the fauces known as the tonsil.

To describe the technic of the application of diathermy to the tonsil, instruments used and the proper setting of the machine, is simple, but the actual application of the current to the tonsil is more difficult than one gathers from the description. The high frequency machine is of great importance. It should have not less than a million and a half oscillations a second, and I prefer one with Leyden jars, insuring a smooth, soft current, without spark or shock to the patient. The next important feature is the adjustment of the machine, which is done in the following manner: Take three-fourths of rheostat setting of machine; make a dead short between the two voltage or surgical diathermy connections, and before turning on the machine, see that the spark gap is closed; after this turn on the machine and open spark

gap gradually until you get a meter reading of 2800 ma.; then take one of the diathermy cords and connect to a piece of heavy block tin 6 in. by 10 in., which is placed upon the patient's back. The second cord, which holds the needle, is attached to the other surgical diathermy outlet. Now you have set the machine before the operation, and an amperage necessary to give coagulation has been definitely fixed. As the tonsil is made up of lymphocytes with very little organized tissue, it is speedily and easily destroyed by this amperage. The consideration of importance is the time of contact with the tonsil and the active electrode or needle. (Nothing but a needle should ever be used, and see that the rubber sleeve covering it is pulled up over the end of the handle, so as not to spark the tongue.) The time is not limited by seconds, but by the reaction of the tissues to the active electrode or needle; when the point of coagulation is reached, a white ring appears around the needle. This requires from one half to two seconds, never longer. These are the three important factors in the technic; first, setting the machine; second, type of active electrode; third, time of contact.

Now, as to the method of applying this to the patient. This is an office procedure. The patient is seated in any kind of office chair desirable, and a large piece of the heaviest block tin, 6 in. by 10 in., is applied to the bare skin of the patient's back and connected by an insulated cord to the machine. I use a 5 per cent solution of cocaine, having wet the cotton on the applicator *only once with the solution*. This I quickly apply to the soft palate, around the tonsil, inside the cheek and the base of the tongue, repeating this procedure five or six times with the same pledget of cotton, but no additional cocaine. I use no more than 4 or 5 drops for the whole procedure. Now the throat and tongue are sufficiently anesthetized. I have never had a patient faint or show the slightest sign of syncope in 23,000

applications. I treat many cases without any anesthetic whatever.

I never inject novocaine for three reasons. First, there is the slight danger from the anesthetic; second, more fluid is added to the field which you wish to dehydrate; third, you get about as much reaction from the fluid injected into the soft tissues as you do from the diathermy. (Use a wooden or glass tongue depressor; further, always have a nurse hold forward the anterior pillar with a hard rubber pillar retractor; never turn on the current unless you can absolutely see the exact location of your needle. If there is one point more important in the technic than another, it is knowing where the point of your needle is, and it must always be turned more or less toward the center of the tonsil.) Now I take the needle, the end slightly curved, and put it from  $\frac{1}{8}$  to  $\frac{1}{4}$  in. into the tonsil, and step on the foot switch, and in from one to two seconds the white ring appears around the needle. Release the current and take out the needle. This procedure is repeated until the tonsil has been covered with punctures about  $\frac{1}{4}$  in. apart. The number of punctures varies according to the size of the tonsil; I often use on large tonsils as many as twelve to fifteen. I now paint the tonsil with some acriviolet, and the patient goes right on with his usual routine of the day.

My usual practice with patients who live in the city is to treat only one tonsil at a sitting. In seven or eight days the patient comes back, the tonsil operated upon has 50 to 75 per cent disappeared, and the other tonsil is treated. Both tonsils can be treated at one sitting and can be entirely removed with one treatment, but I strongly advise against this, as there will be greater reaction, and the patient is more uncomfortable than when only one tonsil is treated at a time. I prefer giving four to six treatments to each tonsil, and they are removed with no great inconvenience. I have not had more than four or five patients who have gone

to bed for a day, or who have had any elevation of temperature, or who missed a single meal, or any time from school or business. I have used diathermy in many cases of acute tonsillitis with splendid results.

The third, fourth, fifth and, if necessary, the sixth treatments, are each distinctly different. You are working in less tissue, necessarily nearer the other throat structures; hence the need for greater care as to depth of penetration of needle. And once more I want to emphasize the constant care as to where the point of the needle is. The last treatments often consist of only two or three punctures, and the last tissue that may be adherent to the posterior pillar can often be best removed by simply laying the belly of the needle against it and slightly coagulating it. I want again to call attention to the special instruments I use. First, a short, pointed, curved needle. This enables one to hook into and slightly elevate the tonsil from its pocket. The needle is used in a handle that locks it and prevents its turning, so one can always tell where the point is. Second, a glass tongue depressor. Third, a hard rubber pillar retractor, to be used by an assistant in each step of the various treatments. The anterior pillar must be retracted and kept away from the needle, or there may be coagulation and extensive edema. It is these seemingly minor, unimportant things that make for the success of the method. And once and for all, remember that electro-coagulation is not electro-dessication or fulguration. From both of the latter methods there is scar tissue, and very unsatisfactory results.

Just a word as to the chief objection I hear raised to the diathermy of tonsils: "You can't remove all of the tonsil and capsule." I defy any anatomist to demonstrate a capsule of the tonsil. We have talked about it so long that we really now believe in its existence. When the tonsil is removed, you have a clean fossa with the anterior and posterior pillars intact, and you are down to the aponeu-

rosis of the constrictor muscles. I am daily removing portions of tonsils left by some former tonsillectomist. Why all this fuss about the diathermy method not removing the tonsil entirely, when it was reported recently in one of our journals that 76 per cent of all tonsillectomies were not clean?

Diathermy is suitable for the removal of all kinds of tonsils and in all cases, regardless of the diseases from which the patients may be suffering. There is no serious condition that I know of which contraindicates the use of diathermy in the removal of the tonsil. I have treated a patient who had been confined to her bed for eight months with rheumatism complicated by a severe heart condition, also a goiter, who, after the removal of her tonsils by diathermy, in a couple of months was convalescing and walking around her room. It is a great pleasure to be able to restore children to a more reasonable degree of health by diathermy tonsillectomy, who have been suffering from nephritis, pyelitis or heart affection. The more important diseases which are considered contraindications to the surgical tonsillectomy are hemophyilia, tuberculosis, nephritis, heart lesions, acute syphilis, etc. These are all admirably suited for diathermy. I have had 6 or 8 cases of hemophyilia. I removed the tonsils in these patients without loss of a single drop of blood. Another large class of cases are the adults who perhaps have been suffering for years from the effects of diseased tonsils, and who will not submit to the old orthodox operation, as they realize the risks of this method, but they are coming rapidly to diathermy. The profession cannot long afford to continue a method that does have serious complications and too many deaths without giving a new method that is absolutely safe a fair hearing.

One more word of caution as to the technic. The tonsil cannot be eradicated in two or three treatments without a great deal of serious reaction, often times

tremendous edema and a great deal of suffering, or with possible confinement to bed. Our method of treating each tonsil five or six times has been devised for the comfort and safety of the patient, not for the convenience and time-saving of the surgeon. If you want every afternoon for golf, do not take up diathermy. Further, I consider that more skill and a better knowledge of throat anatomy are required to perform a diathermy of the tonsil than to do a surgical tonsillectomy. One more caution. In every treatment you must have an assistant retract the anterior pillar, as the slightest coagulation of either pillar causes tremendous edema and excruciating pain, but a proper technic skillfully executed gives nothing but success to a very grateful patient.

Before closing this paper, I wish to call attention to the editorial by Shambaugh<sup>9</sup> on my article<sup>10</sup> where he states that, "as [my] method is so difficult that others working with it fail to get satisfactory results, it is an argument against the procedure." I have never stated that the technic was difficult, but that the technic must be carefully and patiently followed out, and that you must have an intelligent grasp of the agent you are using, and the proper knowledge of the anatomy of the throat in which you are working. If the editor's objection to the difficulty of the procedure was to be seriously considered, Harvey Cushing would have to give up brain surgery, gall bladder operations would be discontinued, a safety pin would have to be left in the bronchi, because these, with other surgical procedures too numerous to mention, are very difficult, and require a great deal of skill and experience on the part of the operating surgeon.

He further states "he has seen patients that have been treated by this method, where the instance of recurring infection in the tonsil fossae still persists." If he wants to be fair, why does he not also state that from his large experience he has probably seen thousands of cases where recurring infection persisted after the surgical tonsillectomy. I think we all court constructive criticism.

I have already called attention to the intimate relationship existing between the tonsils and other glands of the body. This has led me to the question of whether or not the prevalence of goiter in girls of high school age may not be due to the early removal of tonsils. I am going to try to have a short survey made of this subject, and am simply mentioning it here with the hope that others may make a similar observation.

The technic and instruments that we are now using are the results of a gradual development during the past four years, in the removal of more than 2200 tonsils, which has necessitated the use of about 60,000 needle punctures. From this experience I feel sure that the advice given in the foregoing will bring the most satisfactory results to the patient and the surgeon. This method makes the removal of tonsil remnants and the lingual tonsil very easy, and free from any danger of hemorrhage.

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# TREATMENT OF SYRINGOMYELIA BY ROENTGENTHERAPY\*

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## HISTORICAL REMARKS

THE first successful reported case of x-ray treatment of syringomyelia was published in 1905 by Profs. Raymond, Oberthur and Delherm,<sup>1</sup> who during more than a year had kept up roentgentherapy over the spinal cord in a young woman and had achieved an improvement of both the motor and sensory disturbances.

The happy effects of this treatment were immediately confirmed by a number of authors: in 1906 Gramega,<sup>2</sup> Ronzoni<sup>3</sup>; in 1907 Menetrier and Bécère, Beaujard and Lhermitte<sup>4</sup>; in 1908 Holmgren and Wiman,<sup>5</sup> Gavazzenni,<sup>6</sup> Delherm,<sup>7</sup> Desplats,<sup>8</sup> Bienfait<sup>9</sup>; the same year marked the appearance of the thesis of Labeau<sup>10</sup> who reported 6 observations of patients suffering from syringomyelia, treated by roentgentherapy with varying results. In 1909, we find the work of Nobile;<sup>11</sup> at that time, because the new method had run aground in some cases, and because in other cases it had sometimes given doubtful results, there was a growing tendency to regard with doubt the efficacy of x-ray therapy. Nevertheless, in the course of this year Profs. Raymond, Oberthur and Delherm<sup>12</sup> were able to complete the observation of the young woman whom they had reported as treated with success in 1905, four years before, and to demonstrate that the improvement which they had obtained at that time persisted; so that they were able to establish a difference between a spontaneous remission, occasionally observed as a temporary exhibition in the course of the disease, and the durable results following roentgentherapy.

We come then in order upon the work of Raimbaud,<sup>13</sup> and Beaujard<sup>14</sup> in 1910;

Allaire and Denes,<sup>15</sup> Marques, Roger and Beaumel,<sup>16</sup> Huet and Sahatchieff<sup>17</sup> in 1912. Among other important articles appearing in 1912 were that of Bourguignon and Thomas<sup>18</sup> who sought to standardize the technic and insisted on the necessity of making the field of irradiation considerably wider and higher than the presumed site of the lesion, and that of Sahatchieff<sup>19</sup> who was able to collect observations on 6 unpublished cases studied by himself, and finally that of Rupin<sup>20</sup> who devoted his inaugural thesis to this question.

Then for several years it seemed that interest in this subject lagged. Not until 1919 do we find the thesis of Saignol,<sup>21</sup> and it was not until 1921 that new observations began to appear in numbers. Among them we may refer to the following: in 1921, Bourguignon,<sup>22</sup> Lhermitte,<sup>23</sup> Bonnet,<sup>24</sup> and especially Coton, Lhermitte and Beaujard<sup>25</sup> who had the privilege of reporting observations on some patients who had been treated several years before and in whom the improvement obtained then had persisted; furthermore, they were the first authors to publish autopsy findings permitting a control of the efficiency of their treatment.

In 1924 Menetrier and Deville<sup>26</sup> were able to relate the case of a subject treated for syringomyelia twenty years before, and who, as was remarked by Bécère<sup>27</sup> in the discussion, had been treated with "penetrating but not deep" roentgentherapy. The same year Merrill<sup>28</sup> reported a case treated with success, and in 1925 Froment, Japiot and Josserand<sup>29</sup> reported a favorable case.

The number of observations reported in 1926 is considerably larger; 14 cases are credited to Ossinsky and Guise,<sup>30</sup> 14 to

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Charapow,<sup>31</sup> 2 to Wielski and Artwinski,<sup>32</sup> 53 to Keijser,<sup>33</sup> 13 to Heinismann and Czerny,<sup>34</sup> 4 to Proust, Mallet and Coliez<sup>35</sup> who had utilized deep therapy, and 1 case to Coliez and Rebuffel<sup>36</sup> who had been able three years after treatment to demonstrate persistence of the improvement obtained.

Thus we find many authors in agreement that considerable progress has been made in the employment of x-rays in the treatment of spinal cord affections, and especially in the management of syringomyelia, although the various therapeutic measures in use before the commencement of roentgentherapy have remained practically useless. On the contrary, roentgentherapy is not simply a symptomatic remedy; it presents all the advantages of a therapeutic means which is always palliative, sometimes even curative. As far back as 1912 Sahatchieff,<sup>17</sup> after studying the published cases then amounting to about 30, estimated that in 80 per cent of subjects suffering from syringomyelia improvement had followed roentgentherapy. In the literature, which we have carefully examined, we find no statistical summary later than the one just mentioned; but we think we are not far from the truth in estimating at 150 the number of cases published since 1905. To these we may add 16 personal cases in our service of Electro-Radiology at the Hôpital de la Pitié. After a brief resume of what constitutes syringomyelia we shall see what deductions seem justified from the facts having a bearing on the indications, the technic and the results of roentgentherapy, after which we shall summarize and discuss our personal cases and see what deductions are warranted.

#### CLINICAL CONSIDERATIONS

From the clinical point of view syringomyelia constitutes a syndrome which is manifested by the sufferers in different degrees of disturbance of the various motor, sensory and trophic systems, and which in classical cases bursts suddenly upon the masculine sex at adult age, with-

out the origin of the affection having yet been determined.

Sometimes, but already at an advanced stage, syringomyelia manifests itself by a characteristic aspect, the symmetrical atrophy of the two hands being accompanied by disturbances of sensibility of different kinds. Under such circumstances one immediately thinks of syringomyelia, but often the attention is called to the true nature of the malady only after a complete methodical examination of the various aberrations of the nervous system.

All degrees of motor disturbances are to be recognized: at first the delicate movements of the fingers and hands become difficult, then impossible, till at last these patients cannot write, sew or play the piano; then the disturbances extend to the arms, so that the patients cannot any longer raise the arms sufficiently to comb their hair or raise food to their mouths. These symptoms are due in part to a true paresis, in part to the muscular atrophy which suddenly appears upon the thenar and hypotherar eminences and the interosseous spaces which melt away, giving to the hand the aspect known by the classical expressions monkey hand or teacher's hand. Subsequently there supervene the tendinous retractions which provoke the flexion of the fingers and bring about the appearance of a claw (*griffe cubitale*).

The atrophy may invade the entire arm, the shoulders, and even the lower limbs; rarely it involves entire muscles, but it proceeds especially by muscular bundles and is often accompanied by fibrillary jerkings. It is generally observed that the lesions are symmetrical.

Along with these symptoms one should pay considerable attention to the trophic disturbances: those which affect the teguments, local asphyxia, puffiness of the hands, dryness of the skin. Still more particularly symptomatic is the appearance of analgesic panaris or painless ulceration of the tips of the fingers, very important from the point of view of diagnosis. But these troubles may also

invade bones and joints, provoking rarefying or hypertrophic osteitis or various types of arthropathy, among which one should mention the existence of a frequent and precocious dorsal scoliosis which plays a very useful diagnostic rôle.

One may call the sensory disturbances constant; they are observed especially at the level of the upper limbs; they are almost characteristic. The sensation as of ants creeping upon a part, tingling and burning of the affected extremities constitute the subjective troubles. But the capital point of the examination consists of the search for the objective troubles: loss of pain and temperature sense constituting the syringomelic dissociation, and more or less perfect preservation of the sense of touch. The existence of these troubles and their localization give, at least in a certain measure, an idea of the extent of the medullary lesion, to which one cannot attach too much importance in view of the treatment which should be administered. One should know further, at least during the initial period of the disease, that the sensory symptoms present a radicular disposition.

As a general rule, syringomyelia, when not treated, passes through successive stages of evolutionary activity separated by periods of remission susceptible of prolongation over considerable time. It is very important to recognize these periods of arrest of the disease which make it self-evident that only prolonged observation of patients undergoing treatment will permit a judgment of the efficiency of the treatment.

The principal symptoms which we have just described pertain to a typical syringomyelia; in reality the disease can be manifested under a multitude of clinical aspects essentially variable according to the localization of the pathological process. And because the pathological process may extend anywhere from the upper to the lower extremity of the cord and give rise to all kinds of serious symptoms, every case of syringomyelia should be considered

from the therapeutic point of view as a very extensive lesion which necessitates an irradiation exceeding by a good deal the region suspected of harboring the glioma, and which in certain cases means that the entire spinal cord must be irradiated.

#### DIAGNOSIS

According to the clinical aspect of the individual case, the diagnosis of syringomyelia will present a more or less different problem.

It is particularly easy in the typical forms when one discovers the characteristic trophic disturbances: a symmetrical atrophy of the extremities, a painless panaris, and a clear thermo-analgesic dissociation.

On the contrary, the diagnosis is not always easy, especially in the early stages of the disease where the diagnosis demands a profound knowledge of neurology. It seems to us indispensable to emphasize the importance of excluding, because of their similar symptomatology, disseminated sclerosis and amyotrophic lateral sclerosis.

Cervical hypertrophic pachymeningitis, a condition often associated with syringomyelia, may by itself give rise to a clinical picture quite analogous to that of syringomyelia and lead to error. Often also by the clinical manifestations alone it will be impossible to recognize a meningo-medullary syphilis; one will have to fall back on serum reactions, and sometimes only the therapeutic test will permit the dissipation of doubt.

Finally, leprosy and Morvan's disease present with syringomyelia such similarities that certain authorities have desired to consider them identical.

When the diagnosis of syringomyelia has been made, it seems to us that two points merit particular attention:

1. *What is the etiology of the affection?* At the present time we are not in a position to give a satisfactory answer to that question; if this could be determined, it would be possible to anticipate the action

of the irradiations. Lhermitte says: "At present it is impossible to say whether the syringomyelic syndrome is due to a gliomatous or hydromyelic process, or to a pachymeningitis complicated with excavation of the medulla; only complete failure of radiotherapeutic treatment could lead to the diagnosis and justify the belief that we are not dealing with a neoplastic process."

2. *What is the extent of the lesion?* For a knowledge of this extent we depend most of all on the study of the anesthesia and its radicular topography; but this means affords us only insufficient data, and we should always suspect more or less extensive adjacent involvement.

#### PATHOLOGICAL ANATOMY

It may be of value in explaining the action of the x-rays, if we review rapidly the anatomical and pathological facts regarding syringomyelia.

The syringomyelic always show important lesions of the cord. In the high lesions involving the cervical cord, most often with cervical swelling in the Aran-Duchenne type and with swelling of the lower part of the cord in the paraplegic types, the cord assumes the appearance of a soft sac which bursts after its liberation.

Indeed, anatomically the lesions resemble an excavation in the cord which is characterized histologically by neoplastic tissue, glioma. This cavity sends prolongations upward and downward possibly reaching to the bulbar region or to the terminal enlargement; we have already mentioned the possibility of the existence of these prolongations, which are very important from the standpoint of the treatment.

The glioma includes cells with fine prolongations (spider cells) and fibrils infiltrating the zone between the ependymal canal and the posterior horn.

Sometimes the cavity is formed at the expense of the ependymal canal, the epithelium of which preserves its normal character; sometimes, as in the associated

pachymeningitic type, the thickened dura mater compresses the cord and the arachnoid spaces are partially compressed by the neoplastic tissue.

In brief, whatever may be the case as to the nervous lesions, there exist two outstanding processes affecting the organs: compression and destruction.

While in the latter, it is hopeless to expect a useful repair of the tissues as an effect of the treatment (it is known that x-rays do not repair); nevertheless it is logical to think that by causing an arrest of the compression, it may result that the nervous elements, freed by the action of the radiation, may regain a certain degree of vitality and activity. It is this possibility which should guide us in the application of the treatment, which we shall thus be most eager to undertake as early as possible, in the earliest stage of the disease.

#### ACTION OF RADIATION

There is no doubt that if we knew exactly the pathogenesis of syringomyelia, the results of our treatment would improve in precision and efficiency; unfortunately, we are not at all able to affirm that the lesions which present themselves to us under such variable aspects involve different pathogenies; but we well know how the action of x-rays varies according to the nature of the neoplasm.

Hoffmann has advanced the hypothesis of an embryonal origin based upon the coexistence of spina bifida and supernumerary ribs with the syringomyelic lesions.

Guillain has invoked the influence of traumatism.

Other authors, because the site of the spontaneous or traumatic hematomyelia is at the level of the base of the posterior horns, have thought they could associate with this a possible origin of the affection.

Nevertheless, in the opinion of most authors, syringomyelia is due to the development of an intramedullary gliomatous tumor. Since gliomatous tissue is composed of young and relatively differ-

entiated cells, of great cellular activity, the x-rays are capable of exercising on these cells a very pronounced action (Baldwin, Beaujard, Lhermitte), while the adjacent nervous tissue, like the lesions of cicatricial sclerosis, offer in contrast a very considerable radioresistance. It is not less true that the rays cannot destroy all the gliomatous cells, and that some of them can exist in an inactive state for an indefinite period, as has been shown by Bienfait.

Furthermore, whatever may be the pathogenesis of the affection, it should not be forgotten that the law of Bergonié-Tribondeau determines the result of radiation therapy: while it can be efficient in lesions made up of young cells in process of evolution, it can hardly succeed with fibrous lesions of slight radiosensitivity; on the other hand, while it can provoke an arrest of the progress of the disease and even bring about a regression, sometimes of considerable degree, often diminishing the observed troubles, it cannot in any case reconstruct that which has been destroyed; hence the declaration of Ossinsky and Guise,<sup>30</sup> "There can as yet be no question of complete cure."

#### RESUME OF THE CASES OF SYRINGOMYELIA TREATED BY X-RAY

We have tabulated the various cases of syringomyelia treated by x-ray which we have been able to find in the literature, showing the patient's age at the outset of the disease and the approximate duration of the evolution of the affection before the treatment was instituted (Table 1).

If we compare the various data furnished by this table we can at once conclude that the treatment seems to offer the greatest chances of success in the presence of a relatively recent involvement. When of several years' standing syringomyelia seems less and less vulnerable, and an evolution of eight to ten years seems to render it entirely resistant to the treatment.

A case reported by Sahatchieff seems to

constitute an exception to this rule (Case VI, a woman of fifty-three years, the disease beginning only four years before the commencement of the treatment), but there remains some question; an onset of syringomyelia at such an advanced age seems rather late, and one may suppose that the affection remained unrecognized for a long time; furthermore, the patient, a domestic, on her admission to the hospital showed marked atrophy of both hands and forearms with limitation of movements of the elbows and of abduction and of elevation of the arms, and it was during the very course of the treatment that the aggravation of the symptoms was marked.

Reviewing the results furnished by the study of this table, we see that while, on 53 cases observed, Keijser reported 60 per cent of improved patients, the 91 cases treated by various other authors furnished 82 cases improved (about 90 per cent), 6 cases arrested or worse (about 7 per cent), 2 cases doubtful (about 2 per cent).

We personally have had the opportunity of treating 22 patients; 7 of them who simply received a few séances of roentgentherapy we have not included in our study which will therefore deal only with the 15 cases treated in the course of recent years, and which for the most part have been referred by Dr. Babinski who has continued to follow them clinically.

In Table II, where our personal observations will be found, we have adopted the same classification as in the preceding table.

#### RESULTS OBTAINED BY ROENTGENTHERAPY

In a general way, in agreement with numerous authors who have been interested in this question, we have been able to determine that regression of symptoms in the favorable cases, at least as concerns the painful phenomena, begins rather early under the influence of the treatment. We wish to emphasize a rather paradoxical observation recorded by Charapow<sup>31</sup>: the reestablishment of sensibility to pain, at first rapid in the old cases, subsequently

TABLE I

CASES OF SYRINGOMYELIA TREATED WITH X-RAYS

Authors and Date	Age at Beginning. Sex	Duration of Evolution before Treatment	Duration of Treatment	Results Obtained on the Symptoms
Raymond, Oberthur, Delherm, 1905..	22 years, F.	5 years	1 year	++ Motor and sensory, persisting after 5 years.
Raymond, Oberthur, Delherm, 1905..	?	6 years	1 year	++ Motor and sensory
Ronzoni, 1906.....	?	?	?	++
Gramega, 1906, 2 cases.....	42 years, M.	1 year	1 year	++ Motor and sensory
	16 years, F.	A few months	1 year	++ Motor and sensory
Menetrier, Bécèle, Beaujard, Lhermitte, 1907	23 years, M.	3 years	11 months	++ Motor and sensory
Gavazzenni, 1908.....	?	?	?	++
Holmgren, Wiman, 1908.....	51 years, M.	8 years	?	++ Motor and sensory
Labeau, 1908, 6 cases.....	46 years, F.	3 years	3 months	++ Motor and sensory
	42 years, F.	Several years	3 months	--
	22 years, F.	2 years	1 year	++ Motor and sensory
	50 years, M.	15 years	Insufficient	--
	57 years, M.	5½ years	5 months	++ Motor and sensory
	24 years, F.	2 years	4 months	++ Motor and sensory
Desplats, 1908, 2 cases.....	?	?	?	++
	?	?	?	++
Noble, 1901.....	?	?	1 year	Doubtful
Bourguignon, Thomas, 1912.....	26 years, M.	4 years	4 months	++ R. D. persists
Allaire, Denes, 1912.....	30 years, F.	7-8 years	6 months	++ Motor and sensory
Marques, Roger, Beaumel, 1912.....	25 years, F.	4 years	3 months	++ Motor and sensory
Huet, Sahatchieff, 1912.....	47 years, M.	3 years	1 year	++ Sensory R. D. re- gresses
Sahatchieff, 1912, 6 cases.....	41 years, M.	5 years	1 year	++ Motor and sensory
	55 years, M.	3 years	1 year	++ Motor and sensory
	47 years, M.	4 years	1 year	++ Sensory
	27 years, M.	10 years	1 year	
	47 years, M.	3 years	(Observation of	Huet and Sahatchieff)
	53 years, F.	4 years	2 years	--
Saignol, 1919.....	30 years, ?	8 years	1 year	++ Motor and sensory
Bourguignon, 1921.....	?	?	?	?

TABLE I (Continued)

Authors and Date	Age at Beginning. Sex	Duration of Evolution before Treatment	Duration of Treatment	Results Obtained on the Symptoms
Bonnet, 1921.....	? F.		Very long	++ Trophic persisting after 4 years
Menetrier, Deville, Bécélère, 1924.....	26 years, M.	5 years	?	++ Motor and sensory persisting after 20 years
Merrill, 1924.....	24 years, F.	14 months	16 séances	++ Motor and sensory persisting after 6 years
Froment, Japiot, Josserand, 1925....	?	?	?	++ Trophic
Ossinsky, Guise, 14 cases, 1926.....	23 to 46 years 8 F. 6 M.	2-13 years	Relatively short; deep therapy	++ All symptoms
Charapow, 1926, 14 cases.....			Small doses 12 to 18 H	++ 14 cases
Wielski, Artwinski, 2 cases, 1926.....		Short		++ 2 cases
Stormer, Bremer, 9 cases, 1926.....	39 years, ?	1 year	?	++ Motor and sensory
	41 years, ?	7 years	?	++ Motor and sensory
	23 years, ?	1½ years	?	++ Motor and sensory
	?, ?	?	?	Doubtful
	18 years, ?	10 years	?	--
	27 years, ?	4 years	?	++ Motor and sensory
	15 years, ?	10 years	?	--
	25 years, ?	7 years	?	++ Motor and sensory
	44 years, ?	Some months	?	++ Motor and sensory
Keijser, 1926, 53 cases.....			Deep therapy	+ 60 per cent
Heinismann, Czerny, 13 cases, 1926..	20 to 56 years 2 F. 11 M.		Deep therapy	Motor and sensory
Proust, Mallet, Coliez, 4 cases, 1926.			Deep therapy 5000 R	Motor and sensory
Coliez, Rebuffel, 1926.....	20 years, F.	3 years	Deep therapy 5 months	Motor and sensory
Claude, ?.....	59 years, ?	Some months	1 year	Motor and sensory

Note: In this table, the sign ++ signifies improvement; the accompanying phase indicates the symptoms improved. The sign -- signifies aggravation of the symptoms.

progresses only slowly, while just the contrary occurs in the recent cases.

Although Ossinsky and Guise<sup>30</sup> had been able sometimes to observe a transitory aggravation of the subjective disturbances at the beginning of the treatment (more lively pains, more pronounced

weakness, more marked paresthesias, psychic depression), these generally seemed the first to be influenced and, in a large number of cases, disappeared after the first seances of radiotherapy. This is the case, for example, with the tingling, pricking and burning sensations; but we

TABLE II  
PERSONAL CASES FOLLOWED

Sex and Age at Beginning of the Evolution of the Disease	Regions Involved	Duration of the Evolution before Treatment	Regions Irradiated. Duration of Treatment. Number of R Units Given	Results
F. 27 years.....	Quadriplegia	3 months	Cervicodorsal 4 months 7200 R	Motor ++ arms and sensory
F. 23 years.....	Quadriplegia	12 years	Cervicodorsal 9 months 2400 R	Motor ++
M. 23 years.....	Arms	4 months	Cervical 13 months 3200 R	Motor ++
M. 20 years.....	Arms	15 months	Cervicodorsal 13 months 11,600 R	Sensory ++
F. 21 years.....	Arms	2 years	Cervicodorsal 10 months 4800 R	Sensory ++
M. 30 years.....	Quadriplegia	2 years	Cervicodorsal 2 years 2400 R	Motor ++
F. 41 years.....	Right arm	1 year	(1) Cervical 3 months 4800 R (2) Cervicobulbar 3 months 2400 R	Sensory ++ and motor, but only after area No. 2
F. 24 years.....	Arms	16 years	Cervicodorsal 4 months 5600 R	Motor ++ and sensory in part
F. 38 years.....	Right arm	21 years	Cervical 8 months 4800 R	Trophic ++
M. 41 years.....	Paraplegia and right arm	1 year	Cervical 16 months 8000 R	0
M. 55 years.....	Paralysis of the arms	4½ years	Cervicodorsal 5 months 4800 R	--
M. 48 years.....	Paraplegia	4 years	Cervicodorsal 2 years 24,000 R	--
F. 27 years.....	Paraplegia and left monoplegia	20 years	(1) Cervical 12,000 R (2) cervicodorsal 4800 R 6 years in all	--
M. 35 years.....	Paraplegia	15 years	Cervicodorsal 2 months 2800 R	--
M. 23 years.....	Quadriplegia	Congenital ?	Cervicodorsal 3 months 4800 R	--



TABLE II (Continued)

Sex and Age at Beginning of the Evolution of the Disease	Regions Involved	Duration of the Evolution before Treatment	Regions Irradiated. Duration of Treatment. Number of R Units Given	Results
Memorandum of cases not followed (Disappeared)				
28 years	Legs	?	Dorsolumbar 3 séances	
40 years	Left hemiparesis	20 years	Cervicodorsal 3 séances	
63 years	Right hand	3 years	Cervicodorsal 4 séances	
53 years	Arms	Several years	Cervicodorsal 4 séances	
29 years	Right arm		Cervicodorsal 6 séances	
40 years	Left arm	2 years	Cervicodorsal 12 séances 3000 R	
27 years	Legs	Some months	Dorsolumbar 6 séances	

Note: In this table the sign ++ signifies improvement; the accompanying phrase indicates the symptoms improved. The sign 0 signifies stationary. The sign -- signifies aggravation of the symptoms.

should also remark that when a recurrence takes place, these are among the first symptoms to reappear.

These difficulties seem to arise from two causes: on the one hand a compression of the sensory pathways, on the other the muscular contracture which may result from compression of the motor bundles and which is palliated in proportion to the diminution of the subjective symptoms.

In just the same way there is an early improvement of the objective sensory manifestations; Charapow<sup>31</sup> has observed that the improvement of the thermic sense, chronologically the last to be manifested, sometimes can be preceded "either by a perversion of sensation or by a sensation of paresthesia" of a transitory character. Rather rapidly one may note a regression of the extent of the symptoms as a whole, beginning at the extreme upper and lower zones; nevertheless, it will be observed that this regression usually remains incomplete and affects only a small part of the involved regions, the

greater part of which does not show any modifications.

In certain cases, following the first applications of radiotherapy, it is noted that the motor difficulties are favorably influenced; and this improvement which surprises the patient himself constitutes a valuable encouragement to pursue the treatment. If on noting this improvement we fail to make allowance for the phenomena in relation to the paretic manifestations and the contractures which may regress rapidly and even disappear completely, and especially to allow for the more marked symptoms due to the muscular atrophy, which are rarely modified, we may at least sometimes observe an improvement in the motor functions. And it is not rare to observe the recovery of the fine movements of the digits which had become impossible as long as there persisted a marked degree of muscular atrophy.

We should not overlook the rare symptoms of syringomyelia, such as sphincter or psychic troubles, which the treatment is capable of improving. Even more

remarkable is the influence of roentgen-therapy on the patient's general state; *along with an improved sensation of well-being and of a return of strength experienced by these patients toward the end of a series of treatments, it is much more important to emphasize the objective manifestations of this amelioration, that is to say the return of appetite and the increase of weight.*

As relates to the electrical reactions of the involved segments, when there exists a reaction of degeneration the abolition of faradic excitability as a general rule persists very definitely, and in only one case have we been able to note a progressive disappearance of the reaction of degeneration. On the other hand, when there is only a partial reaction of degeneration, we, like other authors, have been able to demonstrate a improvement of the hypoexcitability.

#### DISCUSSION OF OUR PERSONAL OBSERVATIONS

As already mentioned, we have made personal observations in 15 cases, which we propose to analyze. The age of the patients varies from twenty to fifty-five years. The duration of the evolution of the disease before treatment was three months to twenty-three years. The duration of treatment with the rays varied from two months to six years. Our statistics include:

Improved	9 (about 60 per cent)
Unchanged	1 (about 7 per cent)
Aggravated	5 (about 33 per cent)

The observations which we have recorded suggest a certain number of remarks:

1. *Aggravations:* These we have always noted in adults whose affection dated back several years: four, four and one-half, fifteen, twenty, twenty-three. In all these cases we observe that the upper half of the body had been involved.

The duration of treatment had varied from two months to two years.

Let us put special emphasis on 2 cases:

(1) Case XII, that of a man of forty-eight

years, suffering for four years it seems, and who had in two years received over the cervicodorsal region the rather large dose of 24,000 R. Because the symptoms had followed an accident, a fall from a height, it was supposed that in this case we dealt with a traumatic syringomyelia. (2) Case XI concerns a man who was fifty-five years old when his first symptoms appeared; it was not until four and one-half years later that he began his treatment. It is rare to note the appearance of syringomyelia at such an advanced age, and one may properly question (without any means of giving an exact answer) whether the disease had remained latent a certain time or whether by reason of slight clinical manifestations it had simply remained unrecognized.

II. *Unchanged:* We believe the remark just made regarding Case XI may be repeated under this heading, for in that case the treatment seemed without effect.

III. *Improved:* The improvements which we have observed have been met with in adults of twenty to forty-one years. The evolution of the disease before treatment seems to have lasted, at least clinically, from three months to twenty-one years. These patients have received doses of from 2400 to 11,600 R.

If we employ the word improved it is because these patients have not passed from our observation, and because to the apparent arrest of the disease process there has been added regression of certain troubles. We have made most careful note, not only of the subjective modifications from the clinical point of view, but especially of objective manifestations; and if we place emphasis upon the long duration of our observation of these patients, it is because we have already called attention to the fact that the evolution of syringomyelia is often characterized by periods of advance alternating with remissions. If these remissions can be prolonged to the point of permitting one to think of an arrest of evolution, it is natural to suppose that the life expectancy of these cases can

be greatly prolonged. This explains why the observation of Menetrier and Deville,<sup>26</sup> who have been able to report the history of a case treated twenty years ago, presents the greatest interest in permitting an estimate of the value of the treatment.

In this group of improved patients we can see that the duration of the evolution of the syringomyelia before the employment of roentgentherapy has been relatively short. Yet we may call attention to a few exceptions: In Case II the evolution seems to date back twelve years, but already, eight years after the appearance of the initial disturbances, the patient had been submitted to a radiation treatment for involvement of the lower limbs which had resulted in improvement persisting until the renewal of the treatment undertaken for a new involvement of the right arm of twelve months' duration, and treated with success. (2) In Case VIII it is true that the first involvement dated back sixteen years; treated then by radiation it was only after fourteen years that the improvement secured gave place to a new access which fortunately was very quickly controlled by roentgentherapy. (3) Case IX offers a history of the same sort. The evolution dated over twenty-one years. Six years after the commencement of the disease, efficient x-ray treatment of the lesion of the lower limbs (under the control of Dr. Babinski) was followed by a lasting clinical cure; then recurrence at the level of the right arm of only three months' duration before successful treatment with the rays was resumed.

If we review these facts we can say, in agreement with numerous authors who have been interested in this problem, that "in all cases where the sensory-motor disturbances have appeared in early adult life (as is the rule with congenital syringomyelia), x-ray treatment, if begun soon enough, can be expected to arrest the disease."

On the contrary, if the delay following the onset of the disease exceeds ten years, the prospects of success are very much reduced. But it is precisely in these cases

of long-standing syringomyelia, often of late onset and atypical development rendering the diagnosis especially difficult and the prognosis bad, that one should not hesitate to resort to the only therapeutic means which seems to offer any chance of success.

And this all the more because roentgentherapy in no way contraindicates the use of the auxiliary electrical treatments which may be employed with advantage against the motor and trophic disturbances, such as continuous current, the excitomotor current or diathermy.

We should not forget that these treatments demand the greatest prudence by reason of the risk of producing burns in the areas of thermoanalgesia since the patients themselves cannot recognize the menace.

#### TECHNIC

We use systematically the following roentgentherapeutic technic: Spark-gap 25 cm.; intensity 2 ma.; filtration 5 mm. Al; focus-skin distance 30 cm.; elongated fields on each side of the spine, centering on the medullary canal.

This technic corresponds to the recommendation of Bécclère<sup>37</sup> to utilize "penetrating but not deep radiotherapy" which seems to protect from the edematous congestion on one hand and, on the other, the aggravation of symptoms. While, in our personal experience, this plan has always given satisfaction, it is not less true that it has not been adopted by all authors; thus Keijser, Heinismann, Czerny, Proust, Mallet and Coliez, and Coliez and Rebuffel<sup>38</sup> in some recent publications have praised the use of penetrating roentgentherapy which has seemed to them susceptible of determining a more rapid regression of symptoms.

One will irradiate the region of the cord which corresponds to the topographical localization of the nervous symptoms; but it is highly important "to make sure that the treated zone considerably exceeds, both above and below, the site of the localization indicated by the nervous manifestations." We cannot over-emphasize this

point to which Claude has already drawn our attention; we know the existence of the medullary extensions of the lesion from the anatomical-pathological findings here reported. It is thus that in one of our cases, Case VII, it was only after very extensive irradiation over the segment higher than that indicated clinically that we were able to secure the arrest of the syringomyelic process and an obvious improvement.

From these facts, which confirm the frequency of the medullary prolongations of the glioma which we would have no reason at all for suspecting from the clinical symptoms, it has seemed to us almost logical to irradiate systematically the entire spinal cord from its origin to its terminal filaments, taking great care to utilize carefully marked ports of entry in order to avoid overlapping the irradiations.

It is always easy to mark out ports of irradiation by utilizing bony landmarks; or one may employ for this purpose the scheme of opaque cones, called the "spinal cord localizer," with its long axis parallel with the spine, divided obliquely in such a way that it is applied accurately on either side of the vertebral column.

*What doses should be employed in an efficient treatment?* This is a question not easily answered. A study of our tabulation shows sometimes a very considerable variation in the doses employed; only the progress of the case can guide us in our estimate of the useful dosage.

In a general way, we are partisans of moderate doses repeated at varying intervals according to the patients and the evolution of the affection; it is in this way that we decide upon series of 1200 to 1600 R per field. We use the cross-fire method, treating alternately from the right and from the left side of the spine in the course of each series, directing the normal ray obliquely toward the spinal canal. Each séance consists of a dose of 400 R, and we give two séances each week.

At the beginning of the treatment we space out the series over three to four weeks, and with this technic, which we

prefer to that of massive doses given at longer intervals, the treatment may be continued without interruption over several months. And in proportion to the improvement of the patient and as the results become more marked and lasting, we permit a longer interval between the series; thus, certain of the patients, followed up for many years, have been able to receive without skin damage very large doses of x-rays (as high as 24,000 R and more).\*

It is important to devote much care to the skin of these patients, for two reasons: the sometimes very prolonged duration of the treatment and the necessity of being able to repeat it at some time in the future. Through exercising prudence we have been permitted to follow some of our patients during many years, repeating the treatments at intervals as required without having had the slightest difficulty.

#### CONCLUSIONS

1. In brief, our statistics include 159 cases. Of these, 124 (about 79 per cent) have been improved to such a marked degree that in certain cases, small in number it is true, it has been justified to use the word cured. Thirty-three (about 21 per cent) have remained stationary, or have become aggravated.

2. The favorable percentage of our personal cases is somewhat lower than that of most previous reports (60 per cent instead of about 80 per cent).

3. We note, finally, that while in cases dating back more than five years roentgentherapy has achieved some little success, it is also in that group that failures are more frequent.

4. From this collection of facts one may then conclude that in the presence of an affection like syringomyelia, where the evolution of the malady is particularly severe, the use of roentgentherapy permits the hope that in an appreciable number of cases we shall see a considerable improve-

\* It should be understood that all the doses we report as R units should be considered as measured in French R units as defined by Solomon.

ment in the prognosis, but on condition that the x-rays shall be applied early, in young subjects, following absolutely the rule of treating an area much larger than that clinically involved, and following up the treatment for a long time.

5. Let us also remember how important it is to watch the skin and to take care of it as much as possible, and to protect from radiation those regions which later we may be called upon to treat.

6. We think, with Lhermitte, that a failure of roentgentherapy justifies one in supposing, within a certain limit, that a neoplastic process is not the causative lesion.

7. Even in the presence of a very old case, of many years' development, one cannot dare to neglect the only treatment which up to the present time has seemed able to deal with and oppose an obstacle to the progress of the disease.

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# STRUCTURAL FACTORS IN STATIC DISORDERS OF THE FOOT\*

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WITHIN the last year we have been favored with a very interesting and valuable article from Sir Arthur Keith, entitled "The History of the Human Foot and its Bearing on Orthopaedic Practice."<sup>1</sup> In it he implies the existence of two clinical schools of thought in regard to static foot disorders; or to be more exact, he recognizes the present existence of one school as having superseded the other which is now out of date, and seems to assign to me the uncertain honor of being to his knowledge, its single surviving advocate.

I shall not presume to use this occasion as an opportunity for arguing personal ideas, nor would I impose myself upon the courtesy of your esteemed society, were I not convinced that the conclusions which I hold are entertained by some of you at least and that their soundness is established by substantial evidence. Keith has given his support to one side, and I appreciate this privilege of submitting before you the results of studies which contribute to the opposing point of view.

Allow me to quote directly from his article.

Thirty years ago it was not uncommon to meet with surgeons who regarded "flat-foot" as the collapse of a mechanical arch,—one which depended on the shape of bones, and strength of supporting ligaments. I thought this conception, a vitally wrong one for men in practice, would die with the generation which held it, but in this I find myself mistaken. My young friend, Dr. Dudley J. Morton, holds that "the term balance as applied to the foot structure does not refer to muscle activity, but to the arrangement of the bones and ligaments which furnishes a stable base upon which body-weight can be supported with the least demand for muscular exertion and propelled evenly balanced upon the lever axis . . . There is no

need in Liverpool to insist that the longitudinal arch of the foot is dependent on properly and automatically balanced action of muscles in the leg and foot.

The swing from an earlier structural concept of the etiology of static foot disorder, to the later muscular concept, has been so strong that undoubtedly the latter has become the predominating school, not only in England, but also in this country and elsewhere. Its interpretation according to Keith's statement may, I believe, be fairly and briefly stated as follows:

Static foot disorders, especially as they involve the longitudinal arch, are primarily due to weakness of the muscles (supinator and flexor) of the leg and foot, or to a disproportion of strength between them and the opposing muscle groups.

Such an interpretation places the onus of foot disorder upon the muscles; if any bone or ligamentous defects are recognized, as indeed they must be in the more advanced cases, their recognition is so limited as to make one regard them merely as changes secondary to the original muscular fault. Hence, although the bone and ligamentous structures compose the actual weight-supporting framework of the foot, there is no provision within this concept for the possibility of a primary fault occurring in these structures. The concept seems to presuppose that the pattern and construction of this framework are 100 per cent mechanically perfect at the start, in all but obviously deformed feet.

In contrast, the interpretation which those of us who hold the opposing view maintain, recognizes a potentiality of disturbance in both structural and muscular elements of the foot, although we are

\* Submitted for publication, January 16, 1930.

inclined to consider the structural defects as the more frequent seat of primary fault. In the article from which Keith has quoted,<sup>2</sup> I attempted to identify and to differentiate very clearly structural balance and muscle balance. His quotation comprised my definition of the former, but he makes no reference to my discussion of the latter.

It seems needless to say that any concept of static foot disorder which does not include recognition of muscular disturbance also as a possible primary fault in a certain percentage of cases, could hardly lay claim in my opinion to serious consideration; for all organic tissues are liable to imperfection.

When my earlier article was written, the possibility of primary defects being located in the bone and ligamentous structures was appreciated, but at that time I was not able to give them specific identification. Subsequent studies have enabled me to recognize certain structural variations or characters which so affect the normal mechanism of the foot, that they can be classified as naught else than primary or causative factors of static foot disability.

Before describing these structural characters, however, may I be permitted to draw your attention to a serious weakness in the defensive position of the opposing concept.

The muscular explanation of foot disorder acquires its strength chiefly through its wide endorsement, for it is admittedly a widely accepted explanation. But among all the writings discussing foot trouble, and from all the foot examinations which we know have been undertaken by individuals and by organizations, there has not appeared to my knowledge a single table of statistics giving the relative strength of the muscles in normal and abnormal feet, by which concrete proof has been furnished to uphold the muscular concept. Does this apparent lack of proof represent a willingness to allow the popularity of a belief to constitute its verification?

Or is it due to indisposition toward publishing results of examinations which were condemned because they did not conform to a premature conclusion? I do not wish to seem unfair in these questions but I do feel that there is a strange significance in this lack of published proof, and that I am entitled to remark upon it.

#### MATERIAL

The studies from which the present findings have been taken were begun at the New Haven Hospital (Yale University) where 100 metatarsalgic cases were collected for etiological analysis. Later its scope was extended to longitudinal arch disorder by including this type of disability, and also by examinations (clinical and by x-ray) of the feet of incoming student nurses of that institution. Subsequently the work was continued among the student nurses at the Presbyterian Hospital (Columbia University). Over 400 individuals are represented, about half of them being clinical cases; the other half comprising a group of young women whose feet are subject to severe occupational demands and who have been very advantageously available for observation.

The range of study covers not only established cases of static disability in various forms, but also observations of individuals before and after the actual occurrence of symptomatic disorder. It may not be out of place to state here that the disclosure by x-ray of the structural characters about to be described, has made it possible to identify among the student nurses those who were susceptible to foot trouble and who later developed symptoms under stress of their work.

#### STRUCTURAL FACTORS OF FOOT DISORDER

So far 3 structural characters have been identified which can be diagnosed by x-ray, and which specifically exert a vicious influence upon the mechanism of the foot. They are:

1. Laxity of the joint between the

inner cuneiform bones, and between them and the navicular bone.<sup>3</sup>

2. Shortness of the first metatarsal bone.<sup>4</sup>

3. Posteriorly located sesamoid bones below the head of the first metatarsal.

These 3 characters have been named in order of their estimated frequency and importance. They are found in a wide range of variation, from slight to conspicuous. Occasionally they occur as a single factor, but usually 2, or all 3 of them, presenting different degrees of fault, are found in combination.

A fourth character is an enlargement of the second metatarsal bone, particularly in its transverse diameter as seen in a dorsoplantar x-ray view of the foot. This character is of an entirely different nature, being an effect i.e., a normal physiological response to an increased burden thrown upon this bone. It is a constant, and consistent accompaniment to each of the 3 factors mentioned before. Greater age as well as the more exaggerated examples of the structural characters already listed, furnish the more notable degrees of this metatarsal hypertrophy.

The 3 causal characters, it will be noted, involve more or less directly the first metatarsal bone, and since this bone occupies a position common to both the front and mesial sides of the foot, any interference with its normal function must naturally affect the foot in both of these regions. They were first identified and their vicious effect upon the mechanism of the foot recognized, in the study of metatarsalgic cases, anterior foot trouble. Here their disturbing influence is so plainly demonstrable that it may be of advantage to consider this part of the foot first.

#### ANTERIOR FOOT TROUBLE

*The Short First Metatarsal Bone (Fig. 1.):* In a foot with a short (first) metatarsal bone, when body weight is carried forward and the heel raised, as in walking, the head of the second metatarsal becomes the

chief fulcrum of the foot's leverage action because of its more advanced or distal position. Consequently instead of the



FIG. 1.

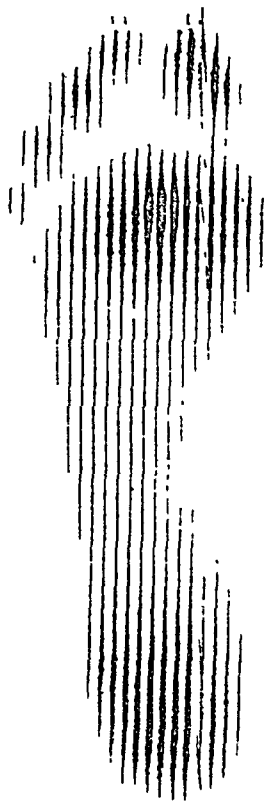


FIG. 2.

FIG. 1. Right foot of young adult female, showing shortness of first metatarsal bone as determined by relative positions of heads of first and second. Second metatarsal bone shows distinctly greater width than three outer metatarsals.

FIG. 2. Kinetographic imprint of foot shown in Figure 1. Heavy marking has registered concentration of pressure exerted upon head of second metatarsal bone as this individual walks.

stresses of body weight being evenly shared by the first metatarsal bone, they become heavily concentrated upon the second.

This interpretation is clearly verified by a kinetographic print of the foot. (Fig. 2.) In this type of footprint, the relative amount of contact-pressure made by the heads of the metatarsal bones is registered by a corresponding heaviness of print as the person under examination walks or stands. The deeply printed area in the location of the head of the second metatarsal bone, has given an automatic



and unmistakable record of the concentration of body-weight placed upon that bone in this type of foot while walking.

identical with that of a short first metatarsal. The kinetographic record presents the same major feature. (Fig. 5.)



FIG. 3.



FIG. 4.

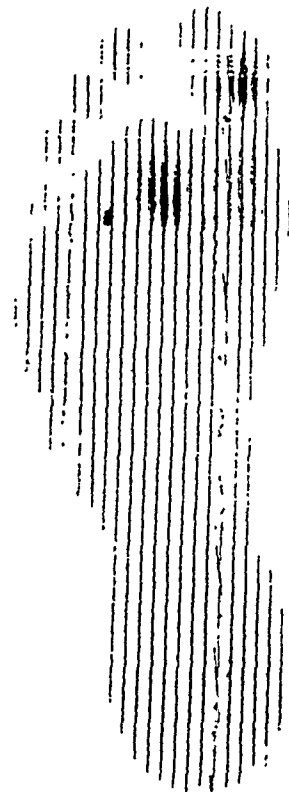


FIG. 5.

FIG. 3. Kinetographic imprint of normal and evenly balanced foot during act of walking. Observe even pressure distributed across entire ball of foot.

FIG. 4. Posteriorly located sesamoid bones. Transverse lines through these bones and through head of the second metatarsal represent relative position of center of weight-bearing contacts of first and second metatarsals. Effect upon mechanism of foot is similar to a short first metatarsal. Note increased stoutness of second metatarsal.

FIG. 5. Kinetographic imprint of same foot, showing same concentration of body-weight upon second metatarsal.

For comparison, the record of the action of a normal foot gives an evenly marked imprint across the entire width of the ball. (Fig. 3.)

*Posteriorly-located Sesamoids:* (Fig. 4.) The sesamoid bones lying below the head of the first metatarsal bone represent the position of the latter's bearing point upon the ground. Their position is relatively fixed because they are enclosed in the tendons of the short muscles. Consequently if their location as recorded by x-ray lies posteriorly to the position occupied by the head of the second metatarsal, the effect upon the foot's mechanism is practically

*Accompanying Hypertrophy of the Second Metatarsal Bone:* Since it can be demonstrated that in the two conditions just described, considerably more than a normal share of body weight is imposed upon the second metatarsal bone, its greater size in these cases may very reasonably and logically be regarded as a physiological hypertrophy. It combines a widening of the shaft and a thickening of the callous walls; but of these 2 types of reinforcing development, there seems to be no constant ratio, for their relative amounts differ in different cases.

This enlargement then, should be

regarded as a symptom rather than as a mere fortuitous condition; moreover, it has the quality of a keynote symptom, for it definitely reveals a disturbance in the normal distribution of weight-bearing within the anterior portion of the foot.

*Hypermobility of the First Metatarsal Bone* (Fig. 6.) This third character is recognized in x-ray examination by an unusual spacing or degree of separation between the inner and middle cuneiform bones. It is an extremely variable character. The combination of clinical and x-ray studies has demonstrated that this apparent separation of the 2 inner cuneiform bones is consistently significant of a laxity or hypermobility of the first metatarsal bone although actually, of the entire hallucal segment or inner pillar, of the foot. Associated with this hypermobility is a similar enlargement of the second metatarsal bone; consequently as might be foreseen in the kinetographic print, a concentration of pressure is also registered by that bone in this type of foot. (Fig. 7.)

The mechanism of this defect differs, however, from that in the 2 formerly described conditions. In the present case, when body weight is placed on the foot, the plantar ligaments attached about the base of the second metatarsal and middle cuneiform bones become taut while there is still a certain amount of play in the ligaments attached to the basal portion of the first metatarsal and its cuneiform bone. Hence, the second metatarsal receives the concentration of body-weight, because the first metatarsal cannot accept its share until the slack in its plantar ligaments has been taken up, and the elimination of that slack occurs only if the foot rolls inward into a pronated posture.

*Occurrence of Metatarsalgic Symptoms:* At this point we may briefly consider the relation of these structural characters to the symptoms of metatarsalgia. Here the hypertrophy of the second metatarsal bone serves as a very effective guide, for with appreciation of the fact that its enlargement denotes a corresponding intensification

of the stresses to which this bone is subject, we cannot avoid recognizing that its basal joints are at the same time



FIG. 6.

FIG. 6. X-ray view of foot with hypermobility of inner pillar (hallucal segment) indicated by distinct separation between inner and middle cuneiform bones resembling backward extension of first intermetatarsal space. Accompanying increased size of second metatarsal bone quite apparent.



FIG. 7.

FIG. 7. Kinetographic print of same foot. A distinct imprint of third metatarsal appears almost as strongly as second. Although foot presented notable, second degree pronated posture, imprint of first metatarsal much lighter than second and third.

subject to a similar intensification of strain. Under excessive or abusive use of the feet, the accumulated effects of function create a state of chronic traumatic irritation definitely localized in the region of the joint and plantar tissues lying posteriorly to the second metatarsal bone, causing a characteristic point of tenderness on palpation. (Fig. 8.) Owing to the close proximity of the internal plantar nerve and its local branches to this region (which now presents some degree of inflammatory congestion), the nerve in turn becomes affected and irritable. Continued use of the feet under

these conditions produces the subjective symptoms with which we are familiar, including the burning sensation of the soles

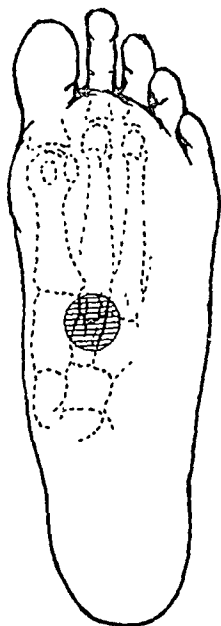


FIG. 8. Showing location of characteristic point of deep tenderness located under basal joint of second metatarsal bone due to chronic strain from concentration of body-weight upon that bone. (*J. Bone & Joint Surg.*)

and the formation of callosities as a result of the localized concentration of weight upon the second metatarsal bone.

#### THE LONGITUDINAL ARCH

Among the cases collected for study of the metatarsalgic disorder, a considerable number (approximately 20 per cent) of them, gave symptoms of strain of the longitudinal arch and presented a pronated posture of the feet. These and other cases of pronation were then studied clinically and by x-ray. As a result, a positive relationship between pronation deformity and hypermobility of the first metatarsal bone was disclosed in a way that could not be mistaken, and which demonstrated that this hypermobility was a prominent factor in these cases.

Analysis of the mechanics of the foot concurs with that finding. According to evidence obtained in studies on the evolutionary development of the human foot,<sup>5</sup>

the functional axis is represented by a line drawn from the center of the heel forward to between the first and second toes. In normal function of the human foot, body weight is carried balanced upon that line. On the outer side of that functional axis, the 4 lateral metatarsal bones sustain this weight and act as a structural buttress to prevent loss of balance in that direction. On the inner side of that axis, the hallux segment is the only structural safeguard to foot balance, and in order to be effective must be a firm and stable member.

In the condition referred to as hypermobility of the first metatarsal, the normal stability of this inner anterior pillar of the foot is impaired; for as explained above, when body weight is imposed upon a foot with this defect, a laxity or slack still persists in the ligaments attached to this inner pillar, while the plantar ligaments holding the outer metatarsal segments have become taut causing them to assume the burden of body weight. The inner pillar cannot become effective as a weight-supporting member until that slack in the ligaments is taken up; and this occurs only as the foot rolls into a position of pronation, upon which event we can all agree, the normal balance of the foot becomes affected or lost.

In a foot with such a hypermobile inner pillar, 1 of 2 things is likely to happen: (1) either it becomes overbalanced into a pronated position, whereby the slack in the plantar ligaments of the inner pillar is taken up and this member is made effective as a weight-supporting structure; or (2) the bowstring action of the supinating muscles and the pull of the flexors must be increased sufficiently to act as a substitute for the bony support that is lacking on the mesial side of the foot.

The mechanism of the foot's action in these alternate conditions is distinctly different, and certainly in neither of them can the mechanism be regarded as normal.

In the first alternative, the foot assumes a pronated posture; it has become un-

balanced with body weight concentrated upon the longitudinal arch, while upon the outer border of the foot, the burden is reduced correspondingly. The condition is vicious because it leads to a steadily progressive deformity and to painful disability. The other alternative imposes a definitely heightened and sustained muscular effort whereby body weight is lifted off the mesial border of the foot and transferred upon the 4 outer metatarsal bones. While by this procedure, a normal posture of the foot may be maintained, the substitution of muscular action to compensate for the structural defect, permits the slackness of the ligaments of the inner pillar to persist, so that although the first metatarsal may appear to have actual contact with the ground, it does not support body weight. As a matter of fact, however, the condition usually resolves itself into a combination of the 2 alternatives; some degree of pronation occurs when at the same time the action of the muscles becomes instinctively heightened to restrict the loss of foot balance. The result of this subconscious increase in muscle action apparently explains the prodromal symptoms of tiredness and aching of the feet so frequently observed in cases of pronation. These symptoms can admittedly be interpreted as due to muscular weakness; but a foot with normal strength of musculature acting under the mechanical disadvantage of such a structural defect, presents a disturbance in muscle balance that is conducive to exactly the same symptoms. The essential difference is causal; if a primary weakness actually lies in the muscles, they should be held responsible; but if some structural fault and not the muscles, furnishes the primary cause of disorder, then it is a shallow interpretation which confuses muscular weakness with an element of mechanical disadvantage under which the muscles act.

A notably short first metatarsal bone may also be associated with pronation deformity. In this case the fault may not be an accompanying ligamentous laxity

at its base, but lie in the inability of the first metatarsal bone to give support because it cannot have strong contact with the ground owing to its shortness. But here again pronation will compensate for the defect and allow the first metatarsal to function, but only under the disadvantage of an unbalanced posture of the foot.

The question naturally arises as to what extent can we estimate the relative frequency of structural defects and of early muscular weakness as the original fault?

Clinical and x-ray studies of the feet of children give evidence that laxity of the first metatarsal bone is commonly present at a very early period, and that its presence in the adult foot is to be regarded as the persistence of an infantile condition. The short first metatarsal bone is evidently congenital. Consequently, there seems to be little chance to postulate any difference in the matter of temporal priority, since both muscular and structural factors may theoretically be carried back to an infantile or prenatal period.

Likewise, although the fibers which compose the ligaments are noted for their resistant, non-yielding quality, we know that ligaments as well as muscles are susceptible of stretching, through clinical observations and as demonstrated by contortionists on the stage and elsewhere. But, we have also seen well muscled, though loosely-jointed, individuals and persons who call themselves double-jointed because they can display an unusual degree of ligamentous laxity in certain joints. If that laxity in a healthy appearing individual should involve a non-weight-bearing joint, such as a very hyperextensible elbow, it would be quite acceptable to regard the condition as essentially ligamentous. Hence, if the laxity be located in the foot so that under body weight the foot assumes a faulty posture, is it not equally fair to believe that here also the fault may be essentially ligamentous? But here again, we are theorizing!

When we study the kinetographic records of pronated feet, however, tangible

evidence if furnished to designate structural fault as the dominating primary cause of longitudinal arch disorder.

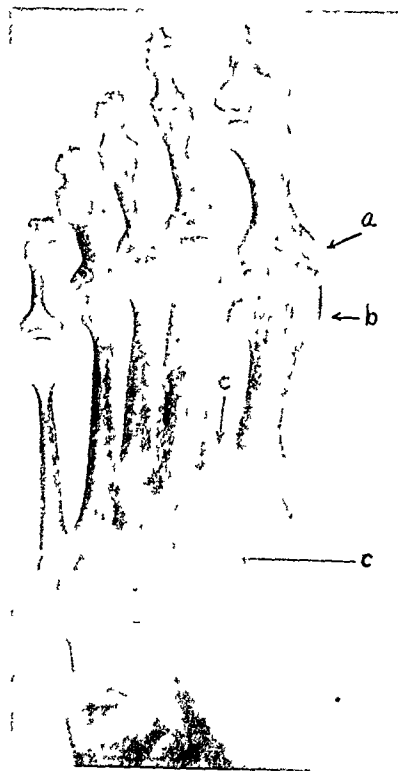


FIG. 9. X-ray view of foot of middle-aged adult possessing all three of structural defects described: (a) short first metatarsal, (b) posteriorly located sesamoids, and (c, c,) inter-cuneiform mobility, with extraordinary hypertrophy of second metatarsal bone, showing greater width than even first metatarsal.

If pronation were essentially the result of muscular weakness with laxity of the first metatarsal bone occurring secondarily, the inward roll of the foot would show by heavy printing an exaggerated contact of the head of the first metatarsal bone under the concentration of body weight upon the inner border of the foot. Then if secondary stretching of the ligaments allowed for a stretching and lowering of the inner arch, the second and later the third metatarsal heads might show an increasingly heavy imprint; but that of the first would always dominate.

But the studies made have given a different result. Pronated feet have typically shown a concentration of pressure under the head of the second metatarsal

which may extend to include the third; there is only a faint registration of the first metatarsal. With increased pronation deformity, there is a tendency for the first metatarsal to leave a stronger marking, but always the heaviest imprint is shown under the head of the second metatarsal. The light imprint of the first metatarsal in these cases allows of but one interpretation, i.e., the original presence of a structural fault, and one which directly affects the inner anterior pillar of the foot.

*Relation of Structural Factors and Subjective Symptoms:* It may seem paradoxical after discussing these structural characters and their harmful influence upon the foot's mechanism, for me to say that they are not of themselves an actual cause of symptoms, but comprise merely the potentiality of foot trouble. There must be a combination with other factors in order to have symptoms develop. The first of these is *function*. Obviously, a foot which is not subjected to the stresses of body weight will never be a seat of static disorder, although it may naturally suffer in other ways. Likewise, if the use of a foot possessing these defects is restricted, symptoms are not likely to occur; for the presence of these defects does not mean a total disability, but they represent a margin of lowered capability as compared with normal conditions. Hence, if functional demands are not carried beyond a certain point, the structural defects may never become an actual source of inconvenience or discomfort.

Another factor is *age*. Since the evidence indicates that these structural characters are traceable to the earliest periods of life, and since subjective symptoms other than postural (which are really objective) rarely occur before the approach of adulthood, usually later, there is a relatively long stretch of time when these defects are present but unattended by symptoms. The earliest appearance of symptoms seems to be coincident with the more rigid development of a maturing foot; so

it may be inferred that the greater elasticity and resiliency of youthful tissues serve to counteract the effect of structural faults toward producing symptoms throughout the earlier periods of life. The early half of adulthood when physical activity is most urgent and occupational demands heaviest, is the time when static foot disorder is most frequent.

But when we consider primitive and non-shoe-wearing peoples as practically free of such disorders, although they are equally liable as the populace of civilized areas to the structural foot defects that have been described, it is apparent that function and age are not sufficient of themselves to constitute the factors necessary for the usual production of symptoms. We must therefore recognize the functional factor in the light of (1) excessive function as imposed chiefly by economic and occupational requirements in our civilized mode of living, and (2) abusive function as function performed under unfavorable artificial conditions, such as poorly designed shoes, hard, level pavements and floors, etc. These artificial conditions do not affect normal feet to any appreciable degree, but they are vicious in their action upon structurally imperfect feet.

Under primitive conditions, the unclothed foot apparently retains youthful resiliency throughout its tissues for a much longer period; it is not ordinarily subjected to protracted periods of uninterrupted function; and the uneven surface of virgin ground induces a continuous shifting of weight stresses so that they are not constantly intensified upon any single part of the foot. In contrast, the conditions of civilization impose a more or less rigid and constricting covering of the foot too frequently attended with other harmful features; the feet are often subjected to prolonged hours of standing, or of work on the feet under the relentless urge of economic necessity; also, hard, smooth and level floors and pavements cause an inevitable uniformity and constancy in the concentration of body

weight upon a defective mechanism causing a cumulative injury in a susceptible part, which has the effect of disabling the entire organ.

It is in these artificial elements therefore, that we find the supplemental factors whereby the structural defects of the feet become changed from a potential to an actual source of static disorder and disability.

#### COMMENTS

Probably no better analogue can be offered to indicate the relation of structural faults to painful symptoms in the feet, then by referring to the common defects of the eye. For with this organ we know that defects may exist even to a fairly marked degree without the individual being inconvenienced by them, or possibly being cognizant of their presence so long as his use of vision is causal and generalized. But let that individual become engaged in some line of work which imposes more constant and severe demands upon the use of his eyes; then it will not be long before symptoms of eye strain develop and accumulate, until he is forced to relinquish that work, or has to seek relief and correction from the ophthalmologist. Here, as in the foot, the presence of defects originally acts merely to cut down the range of capability, for in both instances, symptoms developed only after the reduced limit of usefulness has been overstepped.

But the simile has a further application which should give us who are interested in feet, significant food for thought. We would laugh at the idea of submitting ourselves for correction in errors of refraction, to an "eye-man" who claimed that he could prescribe proper glasses merely by an external visual examination of the eyes without the use of any of the modern instruments by which such errors can be accurately and scientifically diagnosed and measured. Such an individual might well be assigned to a medieval period. And yet we have been content to depend

chiefly upon the same unreliable and unscientific visual method of examination as the only necessary basis for diagnosing and treating our foot cases. It is very rarely that such cases receive even an x-ray examination; and when this is made, it is usually done because we wish to learn if some other factor, such as arthritis, is complicating our problem, and not for any information which the film might be expected to furnish concerning the static trouble.

Our inability or reluctance to devise suitable instruments whereby static disorders of the feet can be scientifically recorded and studied is responsible for a situation which, if we will critically and conscientiously compare with the progressive and up-to-date methods employed by other branches of medicine, we will find to reflect very little credit in our direction. I do not mean that every orthopedic office should contain a room or two rooms filled with elaborate and expensive apparatus to be used for extensive and time-consuming examinations of what we are inclined to regard as a minor ailment. But I do mean that since we, as orthopedic surgeons regarded ourselves, and have the recognition of everyone else, as being the ultimate authority on such disorders, it is incumbent upon us as a group, to discard present primitive and inaccurate methods of handling these cases, and to develop through the efforts of our members who are especially interested in the problem some procedure which is modern and scientific and can be simplified sufficiently for practical use.

I believe that it can fairly be said that the prevailing method of visual examination of the feet, is as primitive a procedure as can be found anywhere within the range of medical practice. Against it, more criticism can be aimed at our group than against any other phase of our work and activities. Its crudeness and ineffectiveness are responsible for the fact that with the exception of only occasional contributions of merit, all the printed

matter discussing static foot disorders is largely a rehashing of ideas held thirty, forty, and even fifty years ago.

It is responsible for numerous conflicting views among us (chiefly involving differences of opinion as to etiology and pathology) which represent a floundering effort to arrive at some true interpretation by theoretical surmise instead of by means of scientific data.

The inaccuracy and futility of this method of examination are demonstrated by the negligible scientific value which may be attached to the innumerable examinations of the feet that have been undertaken by individuals and organizations, and the little that has been contributed to our knowledge of foot disorders in comparison with the time and effort which have been expended on these examinations. It is true that many individuals may have profited physically from these examinations, but so have many headaches been helped by drug-store prescriptions. I do not deny the fact of merit but place a very low value upon the degree of merit.

To that same primitive procedure we can trace the almost complete lack of interest which the general practitioner displays toward foot troubles and his willingness to allow such cases to slip into the hands of the lay shoe and foot device dealer. He has been given no concrete knowledge, only hypothetical ideas of foot trouble to work upon, and as a rule his mind is as confused on foot troubles as that of the ordinary lay person. He is glad to avoid the responsibility of even the mildest type of cases and often refers them directly to the shoeman instead of to the orthopedic surgeon.

To naught else can we lay the responsibility for the encroachment of the shoe and foot device dealers and manufacturers on this field, bringing their foot experts who, after a three week's correspondence course and the filling out of a considerable number of bills-of-sale, usurp the position of authorities on foot trouble and do not hesitate to

match their precocious advice against that of any absent orthopedic surgeon. The financial success of these commercial organizations does not in my opinion, signify the merit of their products, but demonstrates to us where we have failed. Too often their enterprise is prompted by the lucrativeness of their market rather than by a desire to give physical benefits to their customers. We need not refute the altruistic sincerity of all such manufacturers and dealers, but in how many cases will we find that their product is backed by a really intelligent and scientific endeavor to understand the disorders they presume to treat? How many of them can show the facilities and personnel which such study would require? In spite of elaborate and stereotyped advertising propaganda, their goods are little better than a therapeutic hunch and usually comprise only some slight modification of ordinary and conventional devices or patterns. Nevertheless the shoeman could hold the same highly respected and necessary position to the orthopedic surgeons and medical profession, as we observe in the relation of the optician to the ophthalmologist; but this will never happen until the orthopedic surgeon places his work on the foot, upon some modern standard comparable with that attained by the ophthalmologist in his field of work.

Finally, it has allowed mistaken concepts to persist which have little more than their traditional quality to uphold them. Conspicuous in this is the idea of an anterior metatarsal arch, formed by the heads or anterior ends, of the metatarsal bones. There is no such arch or arched conformation, in this particular region of the foot, for each bone has direct contact with the ground through the intervening tissues. The idea implies what amounts to a physical impossibility, for since the heads of these bones are separated from each other, the only structure that might induce that conformation is the weak transverse head of the adductor hallucis muscle which is hardly bigger than the risorius muscle of

the face. Consequently we can well dispense with the diagnostic entity fallen anterior arches for, since there is no arch to begin with, there can be no depression of that arch to end with! Anterior foot trouble is not a morphological change in the position of the heads of these bones, for that is essentially determined by the contour of the supporting surface; but as I have attempted to show, the disorder is an improper distribution of bodyweight upon the metatarsal bones, and this is conditioned chiefly by ligamentous and bony factors.

It may have been noted that no attention has been given to the exaggerated flat foot condition; this has been avoided for the same reason that when the etiology and its bearing upon the pathology of typhoid fever or any other disease are discussed, the moribund or incurable case is not considered relevant to the subject. It is upon the causal factors and their action whereby the individual is changed from a state of health to one of disease, that attention is naturally centered; thus in the present instance, our discussion has properly been limited to causal factors and the early stages of disorder.

Static disorders of the feet are not spectacular. Objectively they present a dreary and monotonous variety in degrees of deformity with or without symptoms, so that in comparison with more acute and outstanding ailments, they give much less incentive for the same earnest analytical study. Within the scope of the muscular faults, a shortness of the heel cord or calf muscles stands out as the single, and the only specific and demonstrable source of disorder. With this one exception, we seem to have been satisfied with generalizations and surmise. But if we are rightfully to maintain ourselves as authorities of this type of ailment, it is due equally to ourselves and to the public who really invest us with that authority, that we show our dissatisfaction with generalizations and turn our attention toward seeking out what is specific and definite. In this effort,



I believe that greatest advantage will lie with those who recognize the structural framework of the foot as the principal seat of primary faults.

The structural defects that have been described in this paper have been definitely identified, and their influence upon the mechanism of the foot analysed. Continuation of such work is necessary in order to give them exact and proper valuation. More factors will surely be recognized as the interest of others becomes more actively engaged in this phase of the problem. And I am satisfied that the present contribution will have served a useful purpose if it disturbs the complacent idea that muscular weakness is a sufficient explanation of these disorders, and prompts diligent search for more definite knowledge.

Always it must be remembered however, that external factors are of equal importance in producing symptoms as factors contained within the foot; static foot disorder is essentially the supplementary action of both, and this should constantly be borne in mind not only in the study but also in the treatment of every case.

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#### DISCUSSION

DR. MATHER CLEVELAND: The importance of foot disorders cannot be overestimated. When we consider the large number of draft rejections for this condition during the late war, we are brought face to face with a major problem.

A large proportion of our practice in dispensary and office is related to foot trouble. The very term orthopedic, properly or im-

properly spelled, suggests to the layman a foot doctor, and if we are to be so considered we should welcome just such a paper as that presented tonight.

I agree heartily with Dr. Morton that foot ailments are exploited very profitably by shoe salesmen, podiatrists, and countless others ill prepared by insufficient or no training to diagnose and treat these conditions.

Dr. Morton has stressed the controversy between proponents of the muscular concept of these static disorders and those adhering to the structural concept. I must say that when one observes the effect of a disease, such as infantile paralysis, in the foot where the musculature is weakened or destroyed and as a result the foot goes into valgus or varus, as the case may be, the rôle of an intact musculature in maintaining a properly balanced foot cannot be disregarded.

In a large number of foot disorders due to contracted tendo Achillis, where the limit of dorsal flexion is from 90° to 100°, we see the calf, which is normally five times as strong as the anterior tibial group, exerting a much greater pull proportionately. Such an individual bears more weight on his forefoot, and in consequence develops painful callosities below the metatarsal heads. In an effort to stabilize this foot, it is usually everted and begins to pronate. These patients have cramps in the calves of their legs, often turn their ankles, and have pain below the longitudinal arch and the forefoot. I cite this large group of foot disorders as an instance of the influence of the musculature on the foot.

The first metatarsal is always described as the shortest and thickest of the metatarsals. I should like to ask Dr. Morton when he considers a first metatarsal abnormally short.

The laxity of the joints on the medial side of the foot has been recognized as a factor in pronated feet. Dr. Morton apparently considers it a cause of this condition. A number of surgical procedures have been suggested to stabilize these joints by fusion along the medial border from the astragalus to the first metatarsal.

The sesamoids are originally dumb-bell shape, with the long flexor to the toe running over the intervening bar. In man, there is only a fibrous sling between the two expanded portions, they are ossicles in the tendons of the intrinsic muscles which produce flexion at

the metacarpophalangeal joint. Each of these sesamoids has a small capsule and joint surface connecting it to the overlying metatarsal head. They are subject to injuries, (fractures, contusions, etc.) the bursa frequently becoming inflamed, the painful sesamoid a real clinical condition to be relieved by surgical removal. My impression is that the sesamoid has a moderate amount of motion and its position is therefore variable.

I am glad to hear Dr. Morton dismiss the theory of an anterior arch, which we use so loosely. The metatarsal arch, as such, is formed by the base of the metatarsal bones; the heads of these bones, in a weight-bearing foot, are on the ground. Dr. Morton has elsewhere shown that the normal line of weight-bearing lies between the first and second metatarsal heads.

The deviation from this normal with a shift to the outer side of the foot, causing increased weight on the second and third metatarsal heads, causes the symptoms we describe as metatarsalgia with a rounded forefoot, convex inferiorly, with painful calluses below the heads of metatarsals one and two.

Dr. Morton has emphasized the importance of the kinetograph in the diagnosis of these foot disorders. I hope he will speak briefly of the practical application of the latter for the clinician. Instruments such as these, as diagnostic aids, however, are a two-edged sword. I recall a description, written in 1820 by Abernethy, of a simple crack fracture without deformity. His observations were infinitely more thorough than those we make, relying as we do largely on the roentgenograms. No machine can excuse us from a full and intelligent use of our eyes and fingers.

Many of us see children with weak feet, due, perhaps, to these structural defects which have been described. Are exercises of any avail in these feet? I should gather from Dr. Morton's observations that there is not much use in teaching these children to shift their body weight to the outer border of the foot because it further aggravates the weakness of the inner pillar of the longitudinal arch. However, some children do it without being taught; they are the ones with weak feet who toe-in markedly to shift the weight off the medial border of the feet. I must say that I have often been disappointed in watching for any marked improvement in some children's

feet with exercises. Such cases may well be due to structural defects.

I should like to ask Dr. Morton if he is ready to suggest any line of treatment for the cases he has described.

DR. E. D. OPPENHEIMER: We come into the world with a certain anatomy, and I believe the anatomy we have when we grow up was there when we were infants, only not so well developed. Our feet are inherited from our ancestors, certainly from our grandfathers, and when a child has so-called flat feet I do not hesitate to say that it is the grandfather's fault. I question whether the structure was the cause of the disability. We are given these lower extremities, but we do with them what we choose. We are trying to get away with a new function on an old anatomy. When we come to a criticism of what is right we must say for what purpose. The short heel cord is the only thing we add to the foot.

Dr. Morton has evidently shown the feet of young ladies. Every one failed to show in the graph heel-weight. They all carry the weight on their toes. If they had their shoes on there would have been a different mechanism; but they have been trained to this since childhood. We have used the limbs that nature has given us, and have attempted to work it out that way. That is our fault. To examine savages and then say what should be the normal foot will not help. I know that no savage can stand fourteen hours behind a counter day after day without trouble. That is what the young girls are doing, and some have no foot complaint. Foot disability is a functional condition in over 85 per cent of the cases. Some people overburden their feet. There must be a limit to everything, but we cannot say what structure or arrangement of the bones will account for that difficulty.

As for the problem, we must face it empirically, and do what we can for the people with the structure they have inherited. One further point: In figuring out the stress on the foot, we must figure it the way it is used; whether the foot is rotated in or out makes an enormous difference.

DR. ARTHUR H. CILLEY: As usual, I don't agree with anybody. The article was altogether too scientific for me to follow, and I don't know anything about the anatomical factors which Dr. Morton has spoken of, except very roughly.

He did not say anything about treatment. It seems to me that in our work on feet the

fault we fall into is primarily the treatment, in that we treat the wrong end of the anatomy. We consider the disabled foot as the cause of the condition, and I personally believe that people get well above their shoulders and not below the knees. They have to learn to use their machine in the way that will carry on the work we are putting our feet to. I don't think there is any question that our feet were not made to do the work we are compelling them to do, to wear the God-forsaken shoes we do and stand or walk all day on nothing that has more spring to it than a rug which we are afraid will slip if we step on it.

I was glad to hear Dr. Morton mention over again the fact that in walking the heads of the metatarsals all come to the ground, that the middle ones do not stand up in the air. It is amusing to see diagrams on the board which purport to show an anterior metatarsal arch. The section which shows the arch is wrong because it goes through the head of the first and perhaps the head of the fifth metatarsal, but does not strike the head of any other metatarsal; it cuts through the other necks which are not supposed to strike the ground, and consequently gives an appearance of an arch which is not present.

I don't believe that the short heel cord is the cause of foot trouble; I believe it is the result. If I believed it was the cause, I should expect to find it in children with weak abducted feet. I have been looking for such a foot for years and don't find it in children, but it is very commonly found in adults; and I believe that when present it is of importance, but I have seen many weak painful feet without it.

The difficulty I find in the anatomical discussion and muscle discussion is that I think both are elements; but I think the chief disability is in the controlling mechanism, which is above the shoulders. I wish to say again that I am sufficient of a mossback to have been unable to improve materially on Dr. Royal Whitman, and I still believe that he knows a great deal

about the foot, and that he knows a darn sight more about the foot than the men who differ from him.

DR. MORTON, *closing*: I have not attempted to discuss treatment in this paper. What I have wanted to do was to urge you who are interested in foot problems to avoid conclusions based upon generalizations and interpretations supported only by visual examinations. Truly scientific interpretations can best be drawn from data which are obtained automatically and mechanically, and which yield the least chance of the personality of the examiner being involved. I have referred to the instruments used in the diagnosis and treatment of eye defects, because they illustrate the mechanical element which is so completely lacking in our method of examination for static foot disorder.

I do not mean to imply that the same mathematical accuracy as is required in the care of eye disorders should apply to foot ailments, and particularly in their treatment. It is the need for some method of identifying and recording foot defects by approved mechanical means that I would emphasize. It is only by such means that we can break away from our traditional and theoretical interpretations of foot troubles and the confusion of conflicting personal ideas in order to replace them with sound and scientific knowledge whereby both diagnosis and treatment can be brought to a higher and scientifically sound standard.

The three structural defects of the foot which I have pointed out to you tonight, are distinct morphological entities that can be disclosed and identified by mechanical means. Their vicious effects upon the foot's mechanism are clearly discernible; hence they constitute definite factors in the pathology of static ailments of the feet. They do not comprise the whole story; nevertheless in their recognition we can, I believe, find justification for reviewing the entire problem in order to gain a clearer knowledge and valuation of both structural and functional factors.



# NEW INSTRUMENTS

## A NEW CYSTOSCOPIC RONGEUR\*

THOMAS J. KIRWIN, M.D.

NEW YORK CITY

SO many cystoscopic instruments are now on the market that it would seem to require some temerity to add soon as they could get time they would fix up something that would take care of that special situation.

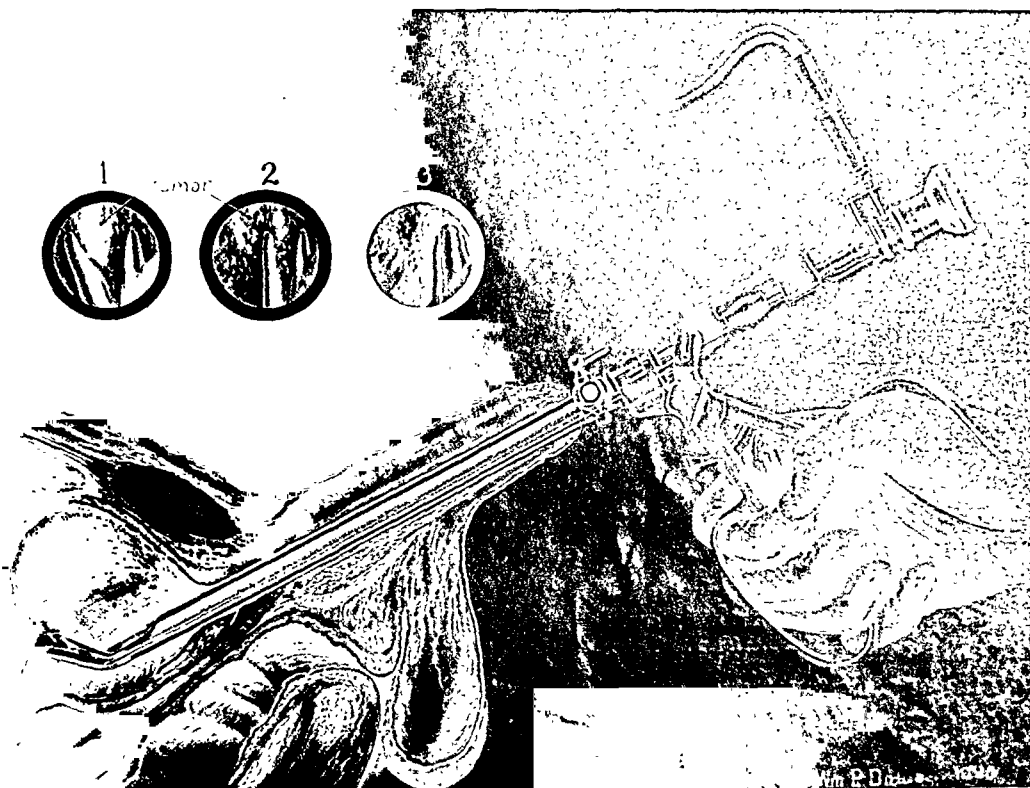


FIG. 1.

another to the list. But it may be argued that the very fact that special devices for use in cystoscopic work are so numerous, indicates rather pointedly that no one of them is absolutely perfect. There are probably few practicing urologists who have not, at one time or another, found themselves in a situation where no single instrument in their possession would suit the exigencies of the case in hand. And most of those so situated have, I am sure, then and there registered a vow that as

Nitze's ingenuity did not stop with the designing of the cystoscope itself. As soon as he had perfected it sufficiently to make it practical for regular use, the need of instruments particularly designed to use through it became urgent. He therefore, set himself to work to meet this demand. One of the most crying needs was for something to seize upon and, if need be, crush stones within the bladder. To fill this need the cystoscopic rongeur we have today first came into being. Casper in

\* Submitted for publication July 15, 1930.

Germany, Luys in France, and Young and a number of others in our own country, have all been concerned in the perfecting of a cystoscope having facilities for illumination and irrigation, it combines the McCarthy fore-oblique telescope affording

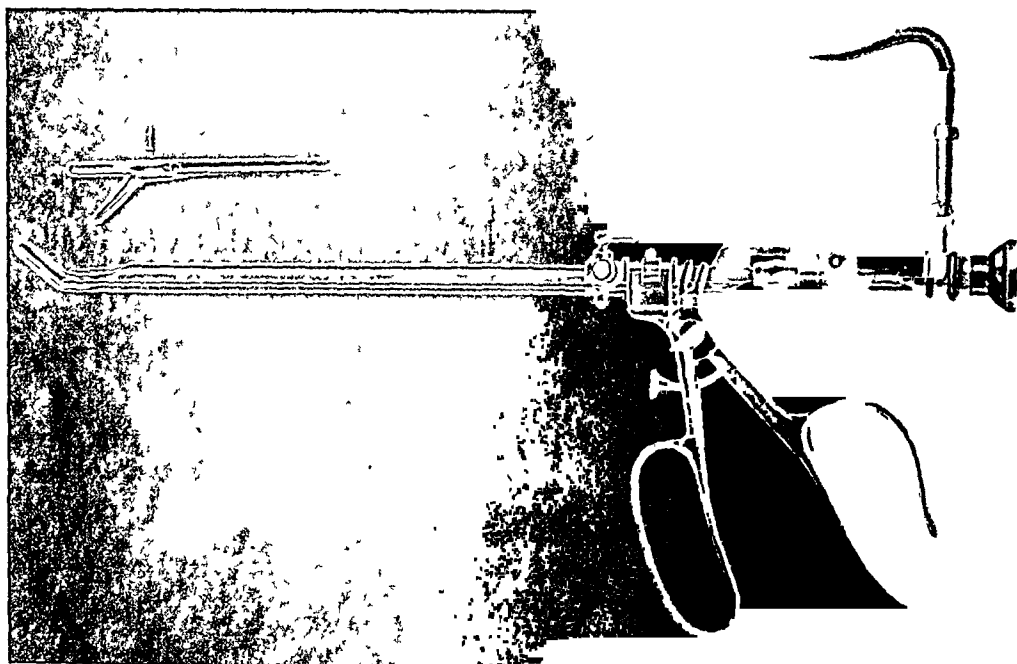


FIG. 2.

of this most useful cystoscopic accessory. Young's rongeur seems to be the one most generally used. Although introduced some time ago (1910) it has never been displaced by such later designs as that of Lowsley, adapted to McCarthy's operating cystoscope. It seems presumptuous to put forward still another instrument designed for the same purpose, yet it has served me better than any of those just mentioned, having all of their advantages and also embodying some that are peculiar to itself. As its blade and grasping jaw are always in the direct line of vision, no matter what angle one may be obliged to search, the operator can always see exactly what he is doing. Moreover, mechanically it is much stronger than any cystoscopic rongeur now available. Only those who have had fragile instruments fail them in time of great need can fully appreciate this second advantage.

This instrument may be described as an irrigating rongeur. With the make-up

direct vision of any portion of the bladder, and a rongeur of exceptional mechanical strength, fitted to deal with any tumor mass likely to occur in the bladder, or to remove any tissue cleanly and expeditiously. Both rongeur jaws are curved, one being fixed. The movable jaw is controlled by a two-jointed rod connected with a pistol-grip handle. Because of the powerful leverage upon which the movement is calculated, the bite of the rongeur is stronger than in any instrument previously designed. The telescope is so arranged that the jaws of the rongeur are always in the direct line of vision no matter what part of the bladder is being explored. The telescope is removable to permit more extensive irrigation if desired. The irrigation system provides facilities for keeping the distending fluid clear at all times. Provision is made for sliding the lamp and objective toward the jaws of the rongeur, according to the location of the operative field.

# CASE REPORTS

## CASE REPORTS BY DR. ARTHUR KRIDA

NEW YORK

### TENDON TRANSPLANTATION FOR IRREPARABLE MUSCULO- SPIRAL INJURY\*

THE disability which follows section of the musculospiral nerve just above the level of the elbow is paralysis of the supinator longus and brevis, of all the extensors of the wrist, fingers and thumb. There is wrist, finger and thumb drop, with preservation of all the flexor mechanism. The sensory loss on the back of the hand is unimportant and is usually, as a matter of fact, compensated for by concentric substitution by ingrowth from neighboring cutaneous nerves.

In this case the nerve was explored fourteen months after injury. Due to the extent and location of the injury, no suture was possible. Tendon transplantation was done at a secondary operation, with the result shown.

H. S., aged seventeen, male. Hospital Ruptured and Crippled, Oct. 17, 1927.

Fourteen months previously sustained a deep laceration just above the bend of right elbow. There was immediate paralysis of the muscles supplied by the musculospiral nerve. Through and through drainage was established and the wound healed up promptly.

On examination at the time of his admission to the Hospital for the Ruptured and Crippled, he presented a paralysis of the supinator longus and brevis, of the extensor carpi radialis longior and brevior, of the extensor communis and of the three extensors of the thumb. The extensor carpi ulnaris was weak but active, and in addition to the wrist, finger and thumb drop, he had a certain amount of ulnar deviation due to the persistence of the latter muscle. There was a very much restricted area of sensory loss at the base of the index finger on the dorsum. There were no contractures.

Operation 1, October 17, 1927. The musculospiral nerve was explored through a curved

lateral incision. The nerve was approached from above, and was found to terminate in an elongated bulb about  $1\frac{3}{4}$  in. in length. The bulb terminated in a mass of scar tissue which was intimately adherent to the underlying condyle.

The bulb was excised. The nerve was progressively sectioned above the bulb, and not for 2 in. above it was an even passably satisfactory nerve section encountered. There was no possibility of suture in this area, and the incision was closed.

Operation 2. November 14, 1927. Jones operation. A long J-shaped incision was made on the dorsum of the forearm, the lower "J" end being just above the wrist. The point of insertion of the pronator radii teres was identified. The extensor carpi radialis brevior, the extensor communis, and the three thumb extensors were identified.

A midline incision of the front aspect of the lower forearm was then made. The tendons of the flexor carpi radialis and ulnaris were identified.

Transplantation A. The tendon of the pronator radii teres was separated from the radius and transplanted into the extensor carpi radialis brevior.

Transplantation B. The flexor carpi radialis was separated at its insertion, passed around to the dorsum through a subcutaneous tunnel, and transplanted into the three thumb extensors.

Transplantation C. The flexor carpi ulnaris was similarly transplanted into the tendons of the extensor communis digitorum.

The incisions were closed with silk. A splint holding the wrist, fingers and thumb in hyperextension was applied.

He was discharged thirty-three days after operation. At the end of his hospital stay all the transplants were active but weak. During his hospital stay, I removed his splint on alternate days and manipulated his fingers, in order to preserve, as far as possible, their flexibility. From the tenth day he was instructed in activating the transplants. He was discharged, wearing his splint, with instruction to discard the same as soon as all the transplanted tendons were acting well.

\* Presented at the Medical Society, New York University, February, 1930.

He discarded his splint four weeks later. Since that time, he has worked at various jobs, and has for some time been working

coarse grating and the mass in the hand would move into the forearm. There was no increase in the local temperature and but little infiltra-



FIG. 1. Range of extension of fingers and wrist obtained by tendon transplantation.



FIG. 2. Range of abduction of the thumb.

at a soda fountain. Two years and three months after operation, his hand is very strong and useful. His range of dorsal flexion of the wrist, fingers and thumb is complete, and is accomplished by the transplanted tendons.

It may be noted that the biceps humeri now acts as the sole supinator, and performs this function perfectly satisfactorily.

### DISABILITY OF THE HAND\*

**CASE 1.** The patient, a business man aged forty-two, in good condition, about two and a half years ago came to the clinic of the Hospital for the Ruptured and Crippled, presenting a small, slightly painful lump in the palm of the right hand at the base of the fourth finger. It was evidently a small cyst of the tendon sheath. It could not be ruptured by forcible compression. He was therefore advised to have it operated upon at that time, but declined, and then had a course of physiotherapy treatment which did not change the situation. He eventually discontinued treatment. A year and a half later he returned having had a great deal of advice and treatment in the interim. He now had a swelling on the ulnar side of the hand extending up the forearm, and whenever he flexed his fingers he experienced pain and heard a coarse grating sound. The examination showed a swelling corresponding to the hypothenar eminence and the lower portion of the forearm. Flexion of the fingers was accompanied by a

tion. The diagnosis was a chronic tenosynovitis of the tendon sheaths of the flexor tendons.

At operation seven months ago the diseased area was exposed by a longitudinal incision. Finding at the operation was a chronic hyperplastic thickening of the sheaths of the flexor tendons of the fingers extending up to 2.5 in. above the wrist. This was divided into two parts, a mass below and a mass above the anterior ligament of the wrist joint. On opening into the lower mass it was found to be filled with two teaspoonfuls of homogeneous perfectly smooth oval rice bodies about  $\frac{1}{8}$  in. in diameter. On flexing the fingers, this mass of rice bodies would pass between the anterior ligament up into the tendon sheaths of the forearm.

The dissection consisted of the removal of all the tissue that seemed inflamed and thickened, the tendons themselves being only slightly involved in the process.

The microscopic examination of the tissue showed it to be chronic hyperplastic tissue without evidence of tuberculosis.

He has made a perfect recovery of function and is relieved of the pain of which he formerly complained.

**CASE II.** The second patient is a marine engineer, thirty-two years of age. He was first seen five and one half years ago. His history was that a few months previously, while in a Syrian port he was attacked by a native with a long knife, who inflicted a long cut on the inner side of his arm and forearm. He was taken to a local hospital and operated upon. The operation was reported to have included suture

\* Read before the Section of Orthopedic Surgery, New York Academy of Medicine, December 30, 1929.

of the ulnar and median nerves. However, gas infection set in and he was very sick for some weeks.

When he came to this country three or four months later he presented a very long scar on the inner side, extending nearly from the axilla to the wrist. The clinical picture was that of a complete severance of the median and ulnar nerves high in the arm. The only muscles that were active were those supplied by the musculospiral nerve. The hand was totally useless functionally, in addition to the hazard of injury by reason of the anesthesia in the median and ulnar distribution.

The first operation consisted of a long incision corresponding in length to his scar. It was found that the ulnar nerve was severely scarred in the middle of the forearm. The median nerve at the point where it divided into its component branches was entirely destroyed. The ulnar nerve was traced through 3 in. of very dense scar tissue, and this segment was excised. The cut ends were of poor quality. However, when the ends were approximated after flexing the elbow and wrist, suture was done. The median nerve was obviously damaged so that no recovery could be expected. The ulnar nerve, by reason of the tremendous scarring and rather unsatisfactory end to end suture, could be expected to function only as a sensory supply in future. Therefore it was decided to proceed to tendon transplantation.

The tendon transplantation was this: the extensor carpi ulnaris was translated into the deep flexors of the three lesser fingers; the extensor carpi radialis longior was inserted into the flexors of the index finger and the long flexor of the thumb. These transplants functioned quite nicely in a few weeks. It was noted, however, that while he had good flexion in his fingers and the terminal phalanx of the thumb, he had no power of opposition of the thumb.

A third operation consisted in opening and splitting into two portions, the long flexor of the thumb in the thenar mass, leaving one at the original insertion and passing the other around the radial side of the first metacarpal bone, in order that it might in some measure act as an opponens of the thumb.

I have since discovered that this operation was described by Steindler. At that time it was unknown to me. Until tonight, I saw the patient last two and one half

years ago, at which time quite satisfactory function was developing.

I mention his case as an example of the efficiency of these transplants in the presence of a complete median and ulnar paralysis. The patient says the feeling in his hand has returned. We must assume that the ulnar fibers grew down to supply the skin and that they finally grew into and supplied the part formerly occupied by the median. He has strong flexion movements of his fingers and thumb and good opposition movements. The hand is useful and he has a strong grasp.

#### DISCUSSION

DR. S. L. KOCH: I was much interested in hearing Dr. Krida say that the microscopic examination of the tissue removed from the first case showed no evidence of tuberculosis. I would think from the clinical picture that the condition was probably a tuberculous tenosynovitis.

DR. AUCHINCLOSS: That Dr. Krida found rice bodies creates a fairly strong assumption that the inflammatory reaction was tuberculosis. We have no right, however, to definitely assume that the presence of rice bodies means tuberculosis, for they may be found in tendon sheaths and in adventitious bursae that are not tuberculosis at all. It has been my experience, however, in ulnar bursa chronic infections containing rice bodies that the bursa sac has been tuberculosis, but it certainly does not mean that this is necessarily so. The dissection for a complete removal of the ulnar bursa investing all of the flexor tendons except the thumb with its prolongation into the little finger is a very interesting one, and well worth while when it is tuberculous. The annular ligament of the wrist should be divided. This is best done by making an oblique incision through it for it leaves the attachments on either side intact and only the middle portion requires to be sutured. Each tendon should be dissected in turn and the greatest care should be taken to avoid cutting the branches of the ulnar nerve to the fingers. Sometimes the superficial palmar arch requires ligation; in fact it is easier to do the dissection if this be done, but the nerves should be spared. A good incision for dissection of the ulnar bursa is indicated in the diagram. The longitudinal



scars in this incision are broken in several places by carrying the incision along flexion creases and it is astonishing to see how difficult

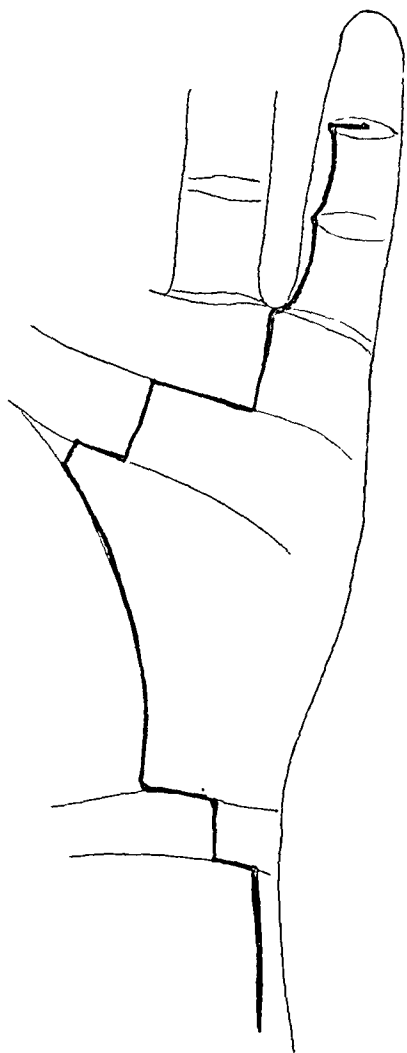


FIG. 1. Diagram of hand to show the way a longitudinal linear scar can be avoided in making a dissection of the ulnar bursa through the use of flexion creases.

it is to see scars in the fingers and hands months or years afterwards if attention to this principle of using the flexion creases as much as possible is adhered to.

DR. LEO MAYER: As for the second case, the result is so remarkable and so far in advance of any similar tendon transplantation of that type that it seems to me there must be another factor which has come into play: that in spite

of what Dr. Krida has told of the difficulty of nerve suture, partial regeneration of the nerve has occurred. Examination of the patient would seem to support that view. Not only are the transplanted muscles working but in addition the contraction of the flexors themselves in the region just below the elbow can be felt. There is almost a complete return of sensation in the fingers, and I question whether that could be possible unless there was some regeneration from the median and ulnar nerves.

DR. KRIDA, *closing*: In answer to Dr. Mayer, the only change which is now present, except for a general gain in strength and usefulness, is that the flexor carpi radialis is active. The branch to that muscle being placed most proximally, may have escaped injury. The matter of the regeneration of the skin area is another story. I have often seen the cutaneous area of supply of the musculospiral nerve recover entirely, knowing at the same time that the nerve had been previously explored and had been definitely sectioned across, so that there was no possibility of fibers of that nerve growing down to that area. It is possible that in such cases a certain amount of concentric substitution takes place; nerves grow in from adjacent sources of supply to take the place of the others. In this case such concentric substitution has been quite complete.

DR. ARMITAGE WHITMAN: I think an historical reference may be in order. While I may seem a little young to be dwelling upon history nevertheless it is encouraging to think that perhaps nowadays less time is required for its making.

When I was a house surgeon all injuries and infections of the hand received their primary treatment in the Accident Room at the hands of the second assistant surgical intern, with the exception that cut tendons were to be reported to the House Surgeon. At the same time anyone suffering from hemorrhoids was welcomed at the front door and operated on in the main operating room with full aseptic precautions. Two years before Dr. Kanavel's book had appeared. Its excellence had at once been perceived by Dr. Auchincloss, who began, I think with us as fourth-year students that painstaking instruction and work upon the hand for which he is so well known.



# FOREIGN BODIES IN THE URETHRA\*

HOWARD S. JECK, M.D.

NEW YORK

FOUR years ago, on the Bellevue Urological Service, I attempted in the following manner the removal of a stone lodged about midway in the pendulous urethra. First, I passed an endoscopic tube down to the stone and tried grasping it with alligator forceps. But since the shortest diameter of the stone was larger than the diameter of the tube, nothing was accomplished. Grasping the stone without the tube was then tried. Several different types of forceps were employed, all to no avail. I then resorted to what was thought would be a certain method of extracting the stone, namely, a perineal external urethrotomy. Attempts to pull the stone backward by forceps introduced through the urethrotomy wound, attempts to push it out with a sound from behind, and likewise attempts to push with a sound in front and pull with forceps from behind were all absolutely unsuccessful. Finally a sort of urethral litholapaxy with forceps was tried and, this failing, it seemed the only procedure that remained was to cut down directly on the stone from the dorsal aspect. This was done and while the stone was readily enough removed, the patient has a urethral fistula to this day. Of course this is the very condition I had made such an effort to avoid. But his infrequent though regular visits to our return clinic have been semi-annual reminders that my effort though sincere, should perhaps have been redoubled.

With the idea that it might be of interest to compare notes on the technic of removal and end-results of foreign bodies in other cases on the Bellevue Service, I have reviewed our similar cases of the past decade. If a stone caught in the urethra may be classified as a foreign body, the total number of urethral foreign body cases during this period is 17.

There were 14 stones and 3 cases of other foreign bodies. The stones were located as follows: Posterior urethra 7; anterior urethra 7, of which 2 were in the terminal 2 cm. Five of the patients had stones elsewhere, 2 in the kidney, 1 in the ureter and 2 in the bladder.

The various procedures for the removal of the stones were:

External urethrotomy (perineal)—6 cases, on half of which an internal urethrotomy was also done.  
External urethrotomy (in penile portion of urethra) directly over stone—3 cases.  
(External urethrotomy, perineal and also directly over stone in penile urethra—1 case.)  
Suprapubic cystotomy—1 case.  
Meatotomy—2 cases.  
Dilation of urethra—1 case.  
Removal with forceps—1 case.

The stones varied in size from a small pea to a large olive.

*End-Results:* There were two postoperative deaths. One patient, fifty-four years old, presumably died of myocarditis, eighteen hours after external and internal urethrotomy had been performed under spinal anesthesia. However it should be noted that his intramuscular phenolsulphonephthalein output was 5 per cent in the first hour and 10 per cent in the second. The other patient, twenty-two years old, died three days after his operation of renal insufficiency. Under general anesthesia the stone, as big as a large olive, was removed from the prostatic urethra through a suprapubic cystotomy wound.

Of the remaining cases, all eventually healed except the one described at some length previously and also one other patient whose urethra was cut directly over the stone. The latter was still passing the greater part of his urine through a urethral fistula at the time of his discharge, one month after operation. All trace of

\* Read before the Section of Genito-Urinary Surgery, of New York Academy of Medicine, January 15, 1930.

him was lost after he left the hospital. In this case, it is only fair to state that there had been three fistulous tracts at

be felt through the tissues at the penoscrotal angle. The pin was removed by perineal external urethrotomy. In both these cases the recovery was uneventful.

The third of the foreign body group, apart from the stone cases, is the one I have chosen to report in detail. I am reporting it chiefly because of the nature of the foreign body but also to illustrate with what comparative ease a sometimes difficult procedure may be turned into a simple one.

This patient, a nineteen year old boy, was sent to me with a note from his doctor to the effect that he had a stone caught in his urethra. After palpating the penis, I did not question his doctor's diagnosis. The foreign body, which was situated just a little anterior to the penoscrotal angle, could be grasped readily enough between the thumb and forefinger and it seemed to be immovable. There was quite a little induration around it. The mass by palpation measured approximately  $1\frac{1}{2}$  cm. transversely and possibly 2 cm. longitudinally.

The boy complained chiefly of passing a small stream when urinating, difficulty in urination and a pain in the perineum that greatly disturbed his night's rest.

Rectal digital examination and careful palpation of the perineum were negative. An attempt to pass a 12 F. olived-tipped silk catheter past the obstruction caused great pain and was unsuccessful.

The urine was cloudy and contained a fair amount of albumin, pus and a few red blood cells; non-protein nitrogen 37, creatinine 1.8.

X-rays and urethrograms showed a definite shadow, presumably that of a stone within the urethra. (Figs. 2 and 3.)

I had definitely made up my mind that a perineal external urethrotomy would be necessary for the removal of the foreign body and had hoped that cutting down on the urethra directly over it might be avoided.

On October 29, 1929, under spinal anesthesia, the foreign body was removed in the following manner:

An attempt to pass a whalebone filiform past the obstruction finally succeeded. With this as a guide a 14 F. tunnelled sound was then passed all the way to the bladder. Here I tried to grasp the stone with a pair of alligator forceps whose jaws were about 2 cm. long. As

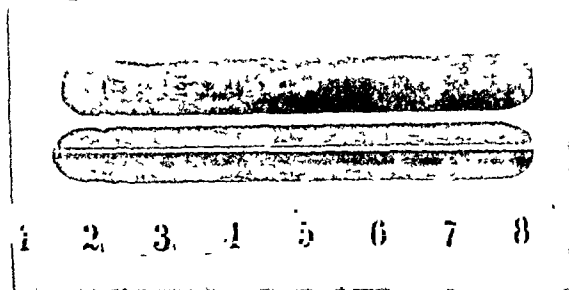


FIG. 1. Two halves of a portion of lead pencil showing lead intact in one of the halves. Note transverse shallow groove near left-hand end of pencil. (See footnote.)

the site of the stone, all of which were included in the incision for the stone.

Of the 3 cases of foreign body other than stone, one was that of a knotted rubber tube. This case was reported in detail by Dr. C. W. Collings before this section several years ago. The tube about the size of a 16 F. catheter contained three distinct knots, the knotted portion being in the posterior urethra with the end of the tube extending beyond the meatus for a distance of several inches. Traction on the tube resulted in nothing but pain. The tube was removed retrograde fashion by means of a perineal external urethrotomy.\*

The second patient in this group presented a hat pin in the posterior two-thirds of the urethra. The point of the pin could

\* It is a strange coincidence that this patient was readmitted to the Bellevue Urological Service with another foreign body (on this occasion in his bladder) the day after this paper was read. Almost three years had elapsed since his previous sojourn as a result of the knotted tube. On this last occasion the foreign body was a portion of lead pencil, about  $6\frac{1}{2}$  cm. long. Near one end there was a shallow transverse groove, evidently for the purpose of attaching a string to the pencil. An x-ray disclosed a long, very narrow, shadow corresponding to the lead of the pencil. Cystoscopy showed that the pencil had separated into its two halves, the lead remaining wholly intact in one of the halves. (See Fig. 1.) Attempts to remove the fragments by means of the operating cystoscope were unavailing because of the difficulty of grasping the fragments in the cystoscopic forceps. Immediately a piece of the pencil was touched, ever so gently, it would float majestically out of reach.

Both fragments were finally removed through a suprapubic cystotomy incision under spinal anesthesia.

was expected, this proved to be difficult. The forceps would grasp the foreign body but on the slightest traction would slip off. Finally,

me until I received a recent communication from his doctor. The patient was discharged from the hospital on the fifth day postopera-

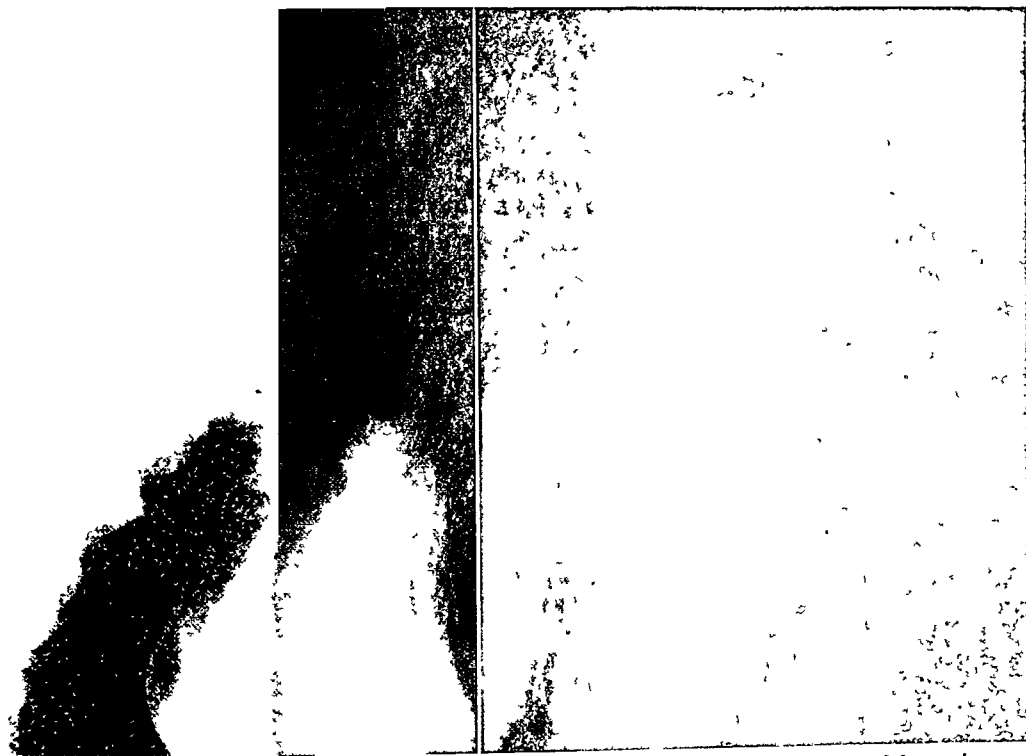


FIG. 2. Anteroposterior view of fragment of bone in urethra.

FIG. 3. Lateral view of fragment of bone in urethra.

just when it seemed useless to continue with this procedure, I obtained a satisfactory hold. Traction alone on the forceps availed nothing but traction plus a sort of milking procedure over the obstruction from without, finally did the trick. And then came a surprise. The supposed stone was not a stone at all but apparently a fragment of bone. A histological examination finally proved this. (Fig. 4.)

A stricture at the site of the obstruction was cut to 30 F. by means of the Otis urethrotome and the operation was completed by passing a 29 F. sound to the bladder.

The patient's past history offers, in my opinion, the most plausible explanation of how the bone got there. In an automobile accident which occurred three years prior to his latest difficulty, he had sustained a rupture of the bladder and a fracture of the pelvis (chiefly of the ascending ramus of the pubis). The fragment of bone probably entered his bladder at the time of the accident or the operation, for the repair of his bladder, which soon followed. It is quite conceivable that, after his bladder healed, the fragment became wedged in the urethra during the act of urination.

Why the patient had complained of such intense perineal pain was quite a mystery to

tive, apparently feeling fine. About a week after returning home he developed a frank abscess which his doctor described a isschio-

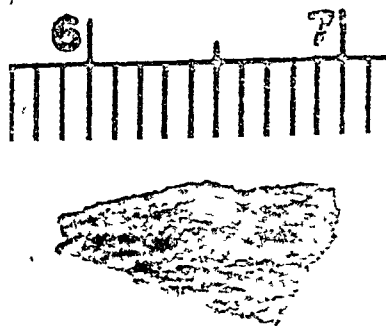


FIG. 4. Photograph of fragment of bone removed from urethra.

rectal. This was drained and his troubles were apparently at an end.

#### SUMMARY

1. Attention is called to the impropriety of opening the pendulous urethra directly over a foreign body.

2. An unusual foreign body of the urethra is described, a fragment of bone.

# The American Journal of Surgery

Editor: THURSTON SCOTT WELTON, M.D., F.A.C.S., NEW YORK

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The American Journal of Surgery is truly independent and enters into no "entangling alliances." It publishes many papers read before the leading surgical societies of the Country, but it is *not* "the official organ" of any organization. Every manuscript is selected by the editors, as worthy of publication—nothing is published merely because "it was read at the meeting."

## EDITORIALS

### PHYSIOTHERAPY IN RELATION TO SURGERY\*

MANY years ago, while a student in the European Clinics, I became convinced of the value of physiotherapy as an adjunct in treatment in every department and specialty of medicine. In the great St. Georg Hospital in Hamburg I saw exemplified for the first time the water immersion treatment of burns and of all extensive open infected wounds. The patients were placed in large bathtubs in which water of an equable temperature was kept constantly circulating, and it was surprising to note the great benefit which these patients received from this type of treatment. In the large Clinics of Berlin, especially the first surgical clinic in which in 1912-1913 I happened to have been an assistant, and

which was under the able supervision of Prof. August Bier, physical methods of treatment were greatly favored for chronic inflammatory lesions such as bone tuberculosis, osteomyelitis, etc. It was in this clinic that Prof. Klapp's methods of functional over-correction of scoliosis of the spine were first instituted. Daily I observed 100 to 150 young children going through exercises which, by muscular counter-pull, corrected vertebral deformities. It was in Bier's Clinic, as you know, that the principle of hyperemia as a therapeutic measure in the treatment of inflammatory and chronic affections of a part was first introduced. This method today does not receive the attention which it merits. From Prof. Bier's Clinic one could

\* Read before the American College of Physical Therapy, Chicago, Nov. 5, 1929.

take a train to Vienna and enter the surgical clinics of Prof. Eiselsberg; and find that in 1912, he was sending most of his tuberculous affections to the clinics of Prof. Rollier in Switzerland, where the sun was curing the joints and bones of tuberculosis. In 1913 there were in Germany immense sanatoria for physical methods of therapy. A well-equipped model of its kind was the large sanatorium at Semmering in the neighborhood of Vienna. In Berlin I noticed in the associated departments of the Virchow Krankenhaus and in the Moabit Hospital and the great Hospital at Haidenhain the remarkable corrective influence of physical methods of therapy, especially the influence which diathermia had upon chronic inflammatory lesions.

Impressed with the great interest that foreign clinicians had in physical methods of treatment in chronic diseases, and noting the improvement in their patients under these different methods, I naturally became convinced of the benefit derived from these therapeutic measures and decided to attempt to apply them, when possible, in the treatment of my own patients. In all the intervening years, from the time of my post graduate student days in Europe to the present time, never have I lost sight of, nor have I doubted the benefits to be derived from such treatment.

In 1914, we in this country were very backward in our application of physical therapeutic measures. However, this was not universal for well do I remember the great hall at the Massachusetts General Hospital where the Zander method of treatment of joint, bone and muscle defects was applied. When on my return from Europe I resumed the practice of surgery there was not in the city of Pittsburgh an accredited physician who limited himself to the practice of this division of therapeutics, and it is only recently that such specialists in treatment have separated themselves from the body of the profession.

Under these conditions I found it necessary in a very modest manner to apply diathermia in my practice. In 1914 I bought a high-frequency machine and found diathermia of value in chronic affections, especially those of bone and of joints and am still a faithful advocate of its use in these conditions. I have also noted the benefit to be derived from it in many chronic intra-abdominal lesions of a mild inflammatory type. My observation in the Army, where physiotherapy was given such acclaim and which produced such remarkable results, thoroughly convinced me of the efficacy of physical measures of treatment as adjuvants in surgical interventions. In 1926 I equipped, as an addition to my office, a physiotherapeutic laboratory. At the present time I have a nurse and an office assistant, two girls who are trained to apply various physical modalities. With the assistance of these two aides and a young physician who is in my office, we have fairly good results, and we are well pleased with the innovation which I have made. I do not solicit nor do I accept patients from other doctors for physical measures of treatment but confine such treatment to patients in my own practice and as helpful factors to other therapeutic measures.

In my discussion of this subject, I will treat only those phases of physiotherapy with which I am familiar. I am not familiar with the different hydrotherapeutic measures which I believe to be of great value in the treatment of disease but of which unfortunately I am not able to avail myself under the conditions that exist in my practice.

With the background that I have given, I shall now try to explain how and in what manner I have found physical measures of therapy of aid to me in surgical work. I shall first consider the patient who is to be operated upon. Irrespective of the character or the type of operation, it is the object of every surgeon to bring his patient to the operating table in the best possible physical and mental condition, so that he

may be resistant to a maximum degree to the shock and interference and physical disturbance which the operation entails. This is especially so in those who are weak and debilitated by a long period of severe illness. Such cases should be earnestly considered and should not be operated upon until conditions are favorable to them, or as favorable as is humanly possible.

We should not permit patients to be rushed into an operation when they are suffering from physical handicaps which can be corrected. Shallow, weak, anemic individuals should be taken in hand and treated by the proper method, so that they become stronger, more robust and healthier. Six weeks or more of treatment may be so conducted that their energy is revived and they are better fitted to endure the strain of an operation.

Thus if the operation is not imperative, patients should be placed in a suitable location and in environment where they will have a maximum of sunlight, good fresh air, quiet and rest. As it is not always possible to bring patients into ideal surroundings, it then behooves us to develop resistant processes in those who remain at home under our personal supervision. They should have their physical well-being developed to the highest possible degree. Of all the factors which produce improved tone, increase resistance, better mental reaction, none I believe has greater value than ultraviolet light, and I can recommend it most enthusiastically as a preliminary treatment for the weak and anemic on whom we consider it necessary to operate. In my hands ultraviolet both as a preoperative and postoperative measure of treatment has proved of great benefit. It acts both as a sedative and an energizing agent.

Rest, baths, massage are all of great value. Anemia should be corrected by methods which are available. If urgency demands, transfusion should be done. Colonic irrigation has proved of some benefit in cases where there is a low-grade

intoxication, the cause of which cannot always be determined. At least under its use patients report to me that they feel much improved and I have noticed personally that they look better, are more active and seem to have more energy. As a measure of therapy I believe it has some value.

*Physical Adjuvants during Operation:* I have had no experience with the method of Crile by which during operation he claims to decrease the incidence of shock to the patient, by passing a high frequency current through the liver, thereby raising the general body temperature. Perhaps this may be of value but from a theoretical standpoint, to my mind, it is not ideal. It is of course necessary during an operation to keep the patient from losing heat, but in a series of 20 operations where rectal temperature curves were plotted, I found that under ether anesthesia there was a constant but slight elevation of temperature.

I find that the physical measures which may be considered as applicable at the time of operation are those modifications of the high frequency current by which fulguration, desiccation and acusection can be performed. It is a great boon to the surgeon to be able to destroy tissue in situ by means of coagulation or desiccation or to remove neoplasms and other growths by means of the high-frequency-cutting current. I have made many incisions through the abdominal wall by the endotherm knife. At times I used it with considerable apprehension and perhaps was unjustly fearful of non-union or extensive necrosis. In some cases where the bowel was attached to the under surface of the abdominal wall, I thought that I might, on making the incision, penetrate into the bowel. All these fears were groundless.

The control of bleeding vessels by coagulation of vessel wall does away with ligatures and has proved a great boon to the modern surgeon. Of all the advancements in the technic of surgery in the last decade, it seems to me that the practical

application of the high frequency current in coagulating dissipation and of incisional cutting because of its unique and useful character, is the most valuable.

*Postoperative Treatment:* In the post-operative treatment of surgical cases those in which abdominal adhesions have been present and in which we apprehend a recurrence of adhesions after operation, peristalsis is stimulated by diathermia and I believe is of value in retarding the formation of the intra-abdominal adhesions. Immediately after operation injection of eserine salicylate and pituitrin is given in association with diathermia. A pad moistened with sterile 10 per cent salt solution is placed over the abdomen with the counter electrode over the back. Low amperage is applied for at least one hour. Increase of peristalsis can be definitely determined by listening through a stethoscope placed on the abdominal wall. The patient feels markedly benefited by this treatment.

Nature is extremely beneficent in its endeavor to induce reactions favorable for healing. Under all the reactions in which healing occurs there is a hyperemia and increased circulation. In consequence, accumulation of corrective factors and reconstructive agents associated with an increment of nutritive elements occurs. In physiotherapy there are two agents which can induce such results. First, ultraviolet radiation which is obtained directly from the sun or by artificial means from carbon arcs or mercury lamps. The manner in which ultraviolet light acts on a part has been the subject of considerable controversy. However, I believe that we can say without fear of contradiction that one effect of this application is hyperemia produced directly in the part under treatment. This hyperemia may be the result of the heat from the lamp or may be the effect directly from the action of radiant energy on the sympathetic nervous system or of both so that the vessels of the part under treatment are dilated. Ultraviolet radiation also has a

peculiar tendency to cause an increase of calcium in the blood. Calcium as you know again acts upon the sympathetic nervous system, produces dilatation of the vessels and seems to be specially localized to any pathologic process taking place in the body, so that its activity becomes more centered upon that localized and pathologic area. It evidently stimulates the formation of red blood cells and produces a hyperemia of the surface vessels of the skin. It is of value in increasing the amount of blood serum calcium and its mobilization in the system.

Massage should not be neglected as a postoperative routine. After abdominal operations it should be applied very carefully over the abdomen. As a general stimulating agent it is of considerable value. A nurse in a doctor's office can apply it very beneficially. Mild degrees of exercise should be instituted very early. An ideal method would be shortly after operation to begin and have those who are able do some well-planned resistant movements. So far I have not applied massage as a routine but believe it of great value, and that good results undoubtedly are to be obtained from its use. Massage may be combined with other physical measures of treatment so that the circulation of the part is stimulated or mobilization of tissues, reconstructive elements takes place. After fractures, massage is of very great benefit.

Where operative interference has induced an induration of tissue, perhaps as the result of trauma or of hemorrhage, and in lesions due to a type of organism which does not induce definite suppuration, radiant light has given good results.

In certain individuals, after trauma, either operative or accidental, there is a rapid proliferative growth of scar tissue, which is termed a keloid. These keloids in the course of their rapid growth may become very painful. With direct application of a Kromayer lamp, keloids are not only controlled but the pain disappears and the tissue becomes soft and pliable. In



every patient ultraviolet light should be applied as soon as a tendency for keloid formation is noticeable in a scar.

In an abdominal postoperative patient there is nothing which arouses more anxiety than do hiccoughs. It is, in many instances, the label for sepsis and the forerunner of death. Even after basic causative agents have been removed as much as is possible, the spasmodic contractions of the diaphragm may persist and cause complete exhaustion. Every surgeon of experience encounters such a condition, every once in a while, and if he does not correct it is aware that death is reaching for his patient.

In a patient, an infected foot was incised and a piece of necrotic bone was removed from the end of the third metatarsal. General sepsis developed and hiccoughs started, which could not be controlled by the usual methods of treatment. Even phrenotomy was unsuccessful. The spasms still persisted though lessened in severity. Morphine and narcotics had no effect. The patient, though sleeping, would continue to hiccough. The only way the hiccoughs could be controlled was by the interrupted galvanic current, the positive electrode over the epigastrium and the negative electrode on the opposite side of the body. After ten minutes of application with 20 ma. dosage the spasm would cease and patient sleep quietly. In a few hours the hiccoughs would again start and would cease on application of the galvanic current.

*Arthritis:* Among the diseases that are particularly in the province of the surgeon are various forms of arthritis. Heretofore the surgeon has assumed charge of a patient with arthritis only when the process has become suppurative. If the surgeon is called upon to treat a case of arthritis, he should first determine whether it is suppurative. I prefer to refer to a medical clinician all forms of arthritis except the static, traumatic, tubercular and suppurative.

When a surgeon assumes responsibility of a patient with arthritis, he should con-

sider not only the means which heretofore have been used by him, such as splinting, application of ice, or heat, to the part; but should also avail himself of the beneficial influences of physiotherapy, remembering that in every person generalized radiation by ultraviolet light increases the general and indirectly the localized resistance to disease. He should remember, particularly, that all chronic suppurative processes are improved by penetrative heat, even when pus is present though it may be necessary to make an incision into the part and evacuate the pus. The involved joint should be placed at rest in order that diathermia and radiant heat may be used to the best advantage. This method combining generalized ultraviolet radiation with localized radiant heat and diathermia, is valuable for the relief of symptoms and as a means of bringing the joint back to approximately normal function.

Bier's hyperemia also is most useful. At the German Surgical Congress of 1913, I saw Bier present over 100 cured tuberculous arthritic cases with nearly perfect motion in the joint.

*Fractures:* Diathermia and ultraviolet rays are to be highly recommended in the treatment of fractures. In these cases also one should not forget that Bier's hyperemia is very definitely indicated.

The diathermia should not be used too early i.e., before the callus has begun to form. There is a growing opinion that hyperemia in the very early stages of a fracture hinders the repair. Massage, by keeping the muscles in a healthy condition, is valuable.

Stimulation by faradic and galvanic currents keeps the muscles in a healthy state so that on resuming activity they can immediately function at full capacity.

*Ulcers:* Indolent ulcers on the leg are the bane of every surgeon. He has found them extremely difficult to heal and even when cured it is very hard to keep them permanently healed. Many of these ulcers are due to the stasis resulting from varicose

veins. The removal of these veins will aid and sometimes cure. Varicosities are now usually treated by local intravenous injection of an agent which is destructive to the intima of the vein. However there are a certain number of these ulcers which do not heal even when the associated varicosities are corrected. There are also a certain number which are not associated definitely with any varicosity. In these, one should seek for a diabetic or syphilitic basis and especially should the blood-sugar be estimated. There is a further group of which the causative factor is extremely difficult to determine. This group in which ulcers are indolent do not have a red granulating base but a grayish floor, the edge is not abrupt nor elevated but seems to slope gradually towards the floor of the ulcer. Epithelium as is known will not heal unless there is granulation tissue, over which it can grow. As these ulcers do not have granulation tissue at the base, it is necessary to stimulate formation of this tissue by irritation with silver nitrate or with the cautery. It is also necessary to keep the circulation of the limb in a high degree of efficiency. The ultraviolet light, the radiant light or diathermia is of considerable value. In one case I have applied the galvanic current with the idea that it would produce a relaxation of the vessels in this area, the current being sent both in a transverse and a longitudinal direction across the ulcer, and reversed frequently. I noticed marked improvement.

*Tuberculous Glands:* Until recently tuberculous glands were absolutely in the province of the surgeon. I, as well as many others, have removed numbers of them, especially the cervical glands of the neck. If conservative we have subjected our patients to repeated operations in the same area, or if radical, have made a very wide excision with a noticeably disfiguring scar. In the last five years I have not operated upon a single tuberculous gland of the neck. If the gland is broken down but does not communicate with the surface I have aspirated the liquid contents

through a needle. I find that it is not necessary to incise these glands and that they recover without scar, without deformity and without the induction of additional drainage. In some instances I treat them according to the method of Calot. When these glands are operated it happens too often that the surgeon scatters the tuberculous material so that he directly is the means of extending the process further along the lymphatic chain. Lymph adenitis usually responds very readily to radium the x-ray or the Kromayer lamp. As a means of keeping up the nourishment of the patient to a high level, cod liver oil, iodides, good food and plenty of rest should not be neglected.

*Pelvic Cellulitis:* A further field which has been preempted from the surgeon to a considerable extent is that of pelvic cellulitis. I can well remember the time when every patient with pelvic cellulitis beyond the acute stage was considered a legitimate case for myself and associates. I was very much surprised in 1926, while attending the gynecological clinics in Vienna, at the few operations for pelvic infections which were performed. In one whole month I did not see operated a single case of pelvic cellulitis. The personnel of the clinic informed me that pelvic cellulitis was treated entirely by heat from hot mud baths and diathermia. The patient enters the mud baths and stays in them for a considerable period. Diathermia was used according to the technic which is customary. Every one of the patients that I saw was doing well under this form of treatment. Each patient was also given protein therapy. In the past four years I have closely followed this plan. I found that in a few cases I had to operate to remove an infected tube. By removal of the tube or tubes, if both are involved, I have been able to accomplish good results. I operate only when importuned by the patient who does not have the time nor the inclination nor the means to continue treatment over a long period. I believe that in 90 to 95 per cent of all cases cure would

follow should the physical methods of treatment be sufficiently persistent.

I have found the direct application of the Kromayer quartz rod of very great benefit in the healing of cervical ulcerations and in the cure of discharges, non-gonorrheal in character, which apparently have their origin in the endocervix.

#### SUMMARY

I am convinced of merits of physiotherapy used in European Clinics.

I am well satisfied with the apparatus for the physical treatment of disease in my own office.

I use ultraviolet light, radiant light, baking, sinusoidal current, also x-ray, radium, massage and heat, each application having its own particular field.

I do not use hydrotherapy, though I believe it to be of great value.

A correct diagnosis must first be made in order to select the proper physical measure of treatment.

The treatment must be prolonged and consistent. It will shorten the period of disability in practically all cases following accidents and injuries.

Physical therapeutic measures must not be blindly applied. At least a general if not a detailed knowledge of their effects must be possessed.

They are of great value and will increasingly become more used in the treatment of fractures, of abdominal adhesions, chronic pelvic inflammation, proliferative cars tissue, and in general infections, both acute and chronic.

R. J. BEHAN.

Pittsburgh, Pa.



## THE RADIOLOGIST AS A CONSULTANT

THE radiological editor has on previous occasions expressed his opinion regarding the ideal relation between the radiologist and the hospital, though much remains which might be said on the subject. It is quite evident that in the average community there is a definite tendency to regard the radiological department of the hospital or the radiologist working in private practice as more or less exalted photographic agencies. Only in the exceptional case does the radiologist function as a consultant in the ordinary sense of the word, and in these instances it is because he has by long years of experience worked himself into that position through the excellence of his radiographic performance combined with a high average of correct interpretation and the exercise of diplomacy in his relation to professional colleagues.

This subject has recently been considered by G. B. Batten writing in the *British Journal of Radiology* for June, 1930. Batten asserts that the requirements of

practicing clinicians from medical radiologists should be exactly the same as the requirements of clinicians from all other qualified specialists; they should apply for and require from the radiologist such aid as will help them to diagnosis and treat their patients in the best possible way for their patients' greatest good. Most of all the clinician requires from the radiologist painstaking fluoroscopic observation, really good films and a careful, well-considered report.

Batten then goes on to emphasize that there is a converse to this proposition and that the radiologist also requires something of the clinician if the best team work is to result. He should demand and obtain everything that any other specialist would require from the clinician to help him to elucidate the problem necessary for the correct diagnosis, and, therefore, for the correct treatment of the patient. He should be given as much of the history as a wise clinician would give to any other specialist and which he believes would help in ascer-





*Walter Dill Scott*

[EDITOR OF THE AMERICAN JOURNAL OF SURGERY, 1905-1928]

*The American Journal of Surgery*  
N. S. Vol. ix, August, 1930

taining the truth about the patient's health. These details would not necessarily be the same in a patient's history when the clinician sends him, for instance, to a bacteriologist or to a radiologist. The important thing is that the clinician should take the radiologist into his confidence, and state in which directions his help is needed. Under such circumstances it will often transpire that the radiologist will be able to suggest additional ways of seeking help which may not have occurred to the referring physician. It is important to bear in mind that the x-ray and clinical methods are "complementary, not competitive" methods of investigation (Barclay).

The relation of the radiologist to the patient should also be carefully considered, especially in view of the exaggerated belief the public have that an x-ray examination can reveal anything and everything. It is sometimes very difficult to answer the pertinent and anxious inquiries of the patient, and it is often just as diffi-

cult to make no answer, especially when the patient imagines that things are worse than they are and that the clinician will not tell him the truth about the consultant's opinion. The radiologist must be as wise and as reticent as possible in such cases, without unduly exciting the patient's fears. Someone has suggested that if patients are anxious and demand to know the result of the radiological examination, the radiologist might say, "I have only part of your story. If I took down a book from that shelf and tore out a few leaves and gave them to you, you would think it a silly proceeding, because you would not have the finish of the story; neither have I."

The radiologist should treat the clinician in a truly professional and consultative way, as Batten says, making it his aim to help him in every way for the patient's benefit without spoken or implied criticism of any opinion the clinician may have expressed.

JAMES T. CASE.



DR. Walter M. Brickner, who was editor of THE AMERICAN JOURNAL OF SURGERY from 1915-1928, died of angina pectoris at Atlantic Beach, Long Island, July 22, 1930, in his fifty-third year. The American Journal of Surgery is glad to be able to publish the following appreciation by one of his best friends



WALTER M. BRICKNER



(1876-1930)

AN APPRECIATION

HOWARD LILIENTHAL

A handsome, slender, bright-eyed youth, Walter Brickner appeared before the Examining Committee at Mount Sinai Hospital competing for a place on the House Staff. It was then that I first met him. I was assisting Dr. A. G. Gerster, Examiner in Surgery.

The Phi Beta Kappa symbol gave promise of scholarship and brilliancy which was confirmed as soon as he began to

speak. He easily won the honors of the examination.

Throughout his Hospital Service Dr. Brickner displayed, in addition to the expected conscientiousness and industry, a delightful whimsical humor which lent a charm to everything he said or did and gave much joy to his many friends both within and outside the profession.

With the skill and originality which

brought success in Surgery, a fine technical quality set his writing at a high level and distinguished the character of his contributions to the literature. Especially in his work on the treatment of actinomycosis of the pelvic recesses and in his articles on subacromial bursitis there was a clearness of thought and expression which made reading easy and which forcefully carried his message. What more natural than that with such talent he should be attracted to the field of medical journalism and that finally he should achieve a prominent editorial position. For many years, under his management, the AMERICAN JOURNAL OF SURGERY developed and became more and more attractive to important contributors both here and abroad.

The World War reached out and at last drew our country into its grip. To Captain Brickner, later Lieutenant Colonel, was given the responsibility of assembling the group of men who became the enlisted personnel of Base Hospital No. 3, also known as the Mount Sinai Hospital Unit. With prophetic insight he selected from the hundreds who applied, those who were best qualified to fill the many and varied stations which were to be parts of a great military hospital. Steam fitters, bakers, carpenters, chiropodists, business men, bookkeepers, druggists, chauffeurs—all in correct proportion, rich and poor, were

made into one orderly body; and when the time came for us to take up the assigned task our parent Hospital in New York was right to be proud of us.

Overseas Dr. Brickner, then a Major, rendered valuable and patriotic service both at the Base and in Evacuation Hospital No. 8 near the front. Through it all his exquisite humor never failed while his personal care and tender sympathy gave last comfort to those whom his skill could not save.

Back from the War Colonel Brickner, now once more a New York Surgeon, became active in military organizations and, for a time was Surgeon on the Staff of the Manhattan Chapter of the Military Order of the World War.

He resumed his position at Mount Sinai Hospital and later became Chief Surgeon of the Hospital for Joint Diseases. Dr. Brickner was also honored by an appointment as Skeletal Surgeon to Morrisania Hospital.

He was a Fellow of the New York Surgical Society and of the Academy of Medicine and was associated with other professional bodies.

And now, at the height of his career, he is gone! All those who knew him grieve over the loss of a faithful friend and comrade while our profession will sorely miss an outstanding figure.



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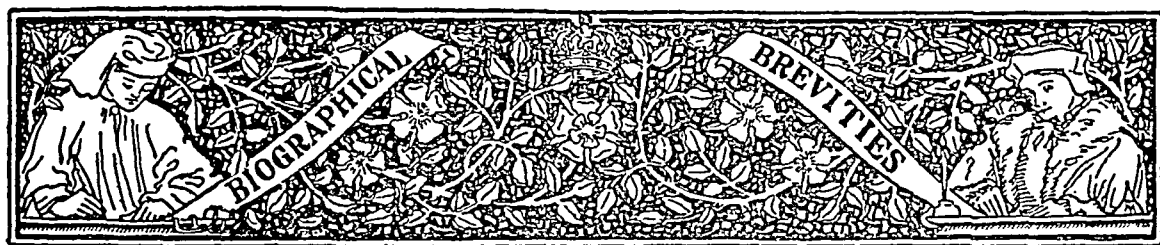
BARTOLOMEO EUSTACHI

[1524-1574]

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BIOGRAPHICAL BREVITIES  
"Eustachian Tube"

*The American Journal of Surgery*  
N. S. Vol. ix, August, 1930



## “EUSTACHIAN TUBE”

**H**E was called Eustachius. His name was Bartolommeo Eustachi. He was one of the early anatomists now called great, and he stands a mountainous figure against the background of his time. He was born in 1524, a romantic age; also, a dangerous age for free thinkers and those with exceptional talents. In the main Galen's teachings were accepted as scientific finalities up to the advent of Vesalius. Thereupon was inaugurated a new era that many years later gave birth to what we term modern medicine. However, although Eustachius was a natural genius in discoveries, at the same time he was opposed to accepting the newer teaching. He remained a Galenite.

Eustachius was professor at the Collegia della Sapienza in Rome. Here, in 1552, he completed his “*Tabulae anatomicae*.” This, in the main, has kept his name fresh to posterity. He drew the plates but they remained unprinted in the Papal Library for one hundred and sixty-two years. Then Pope Clement XI made a present of the engraved plates to his personal physi-

cian, Lancisi, who sought the advice of Morgagni, another anatomical genius. Morgagni urged that they be published. In time they were published by Morgagni who combined them with his own notes (1714). These were the first anatomic plates on copper.

Eustachius is credited with the discovery of many things. He discovered the Eustachian tube, the thoracic duct, the suprarenal bodies, the abducens nerve, and also described the origin of the optic nerves, the cochlea, the pulmonary veins, the muscles of the throat and neck, and gave the first correct and accurate picture of the uterus. He is credited with having written what was in his time the best treatise on the structure of the teeth, giving the nerve and blood supply.

He died at an age today called young. Then, when life was not a simple affair and humans aged before maturity ended, he no doubt was called an old man. At his death in 1574 he was fifty years old.

T. S. W.





[From Fernelius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

STUDIES IN PALEOPATHOLOGY, XXVI

PLEISTOCENE LUXATIONS\*

ROY L. MOODIE, PH.D.

SANTA MONICA, CALIF.

## INTRODUCTION

THE purpose of this paper is to describe accurately and interpret logically, the types of luxations seen in the skeletons of the Pleistocene mammals from the Rancho la Brea. Some of the elements showing partial luxation had been fractured and one of these bones has been described in another connection and is noted further on.

A study of the relation between the angle of torsion of the femora of the giant wolf and luxations has been considered in this study to see if the twisting of the shaft can have had an influence on the degree of luxation. I shall devote a section of this essay to a consideration of the problem of torsion.

I have been engaged in this study during several years, and have discussed the problems involved with several individuals experienced in orthopedic surgery. My chief obligations are to the members of the staff at Hamann Museum of Western Reserve University. Dr. Todd came to Los

Angeles and went over all the materials with me, and I have profited greatly from his suggestions.

Three types of arthritic disturbances are described in this paper. The first is that of loss of head of femur due to an infection in the hip-joint. Second, the complete luxation of traumatic origin, and third, partial luxations as described in the pelvis of the sabre-tooth and in a femur of the same animal, as well as numerous examples in the wolf. One has to make an arbitrary choice from the wolf material for there are dozens of examples of arthritic disturbances grading out from partial luxations to very slight arthritides.

## MATERIALS

I have had entire access to the unrivalled collections of Pleistocene mammals from the Rancho la Brea at the Los Angeles Museum, where there are many thousands of limb bones and pelves, chiefly of the giant wolf and sabre-tooth. I have examined the entire collection of great ground

\* I am under special obligation to members of the staff of Hamann Museum, Western Reserve University, Cleveland, Ohio, for help in the interpretation of the lesions described in this paper. Dr. T. Wingate Todd sent very welcome financial aid with which the illustrations of this essay were secured. Dr. C. A. Hamann determined for me the angle of torsion in a series of twelve selected femora of the giant wolf. Submitted for publication September 13, 1928.

sloths, sabre-tooth cats, and several other species of mammals, and the luxations described here are about all there are. The

of southern California, during the Pleistocene, an animal with a dislocated joint would be so severely handicapped that his

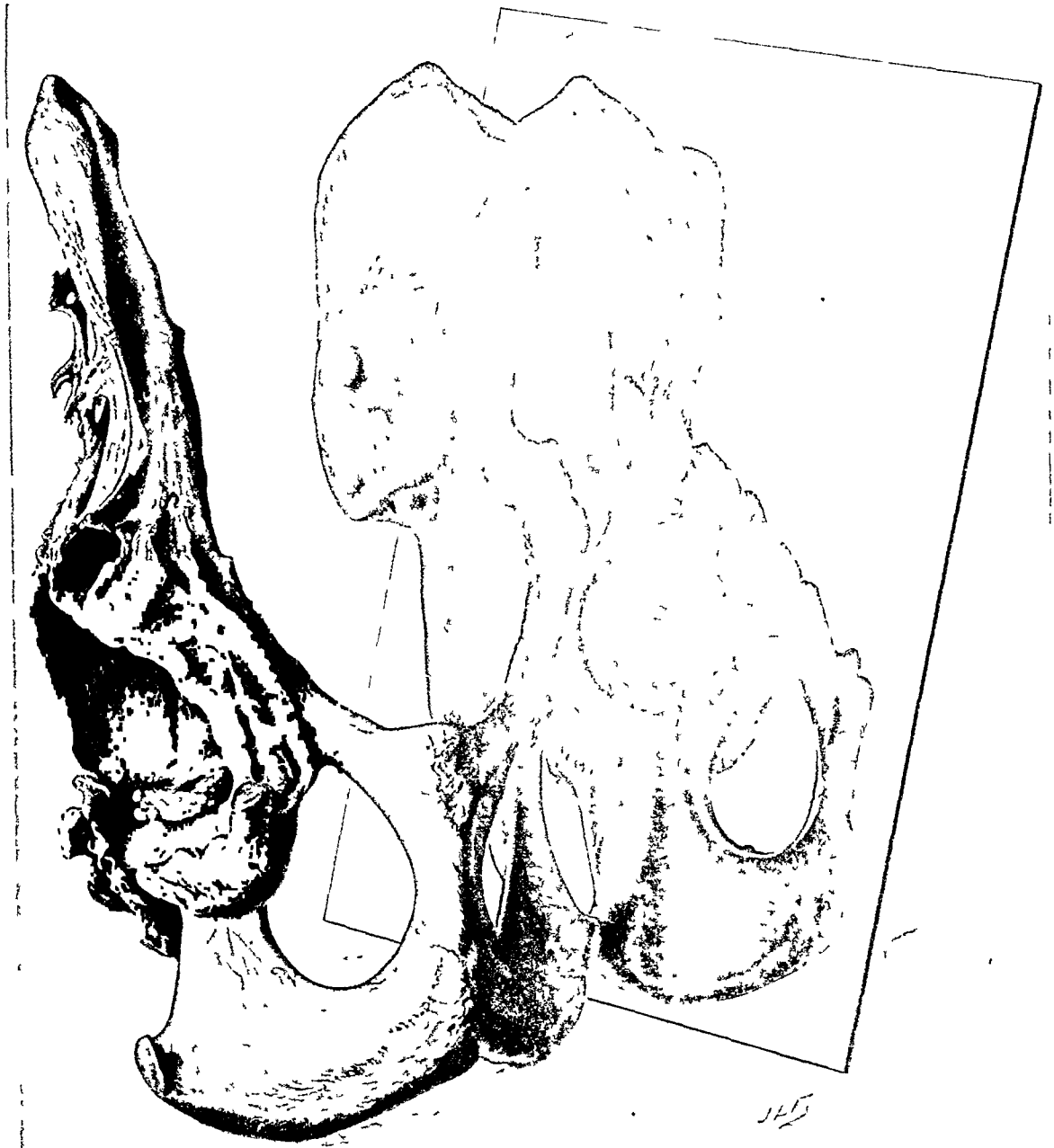


FIG. 1. Mirror drawing of pathological pelvis of sabre tooth (*Smilodon californicus*), Pleistocene, Rancho La Brea, showing both rami. It is evident that pathological changes are restricted to right ramus (shown on left in the picture). All other parts of pelvis are normal. Drawing depicts oblique, ventral view of pelvis, with diseased, distorted acetabulum, and surrounding areas, to left. On right of picture the left acetabulum and pelvic ramus shown, reflected in a mirror, indicated by rectangular field. Eburnated area of diseased acetabulum shown to extreme left. Another view of pathological ramus shown in Fig. 9 Drawing by John L. Ridgway.

greatest number of luxations, partial and complete, occur among the giant wolves. It will be at once evident that in a territory teeming with enemies, as was this part

continued existence would be very doubtful. He would soon fall a prey to his enemies.

I have measured several hundred femora

of the giant wolf with an osteometric board, and have determined the degree of torsion with a tropometer loaned me by the

count is based on a survey of an enormous amount of material. All comparative statements have been checked again and again

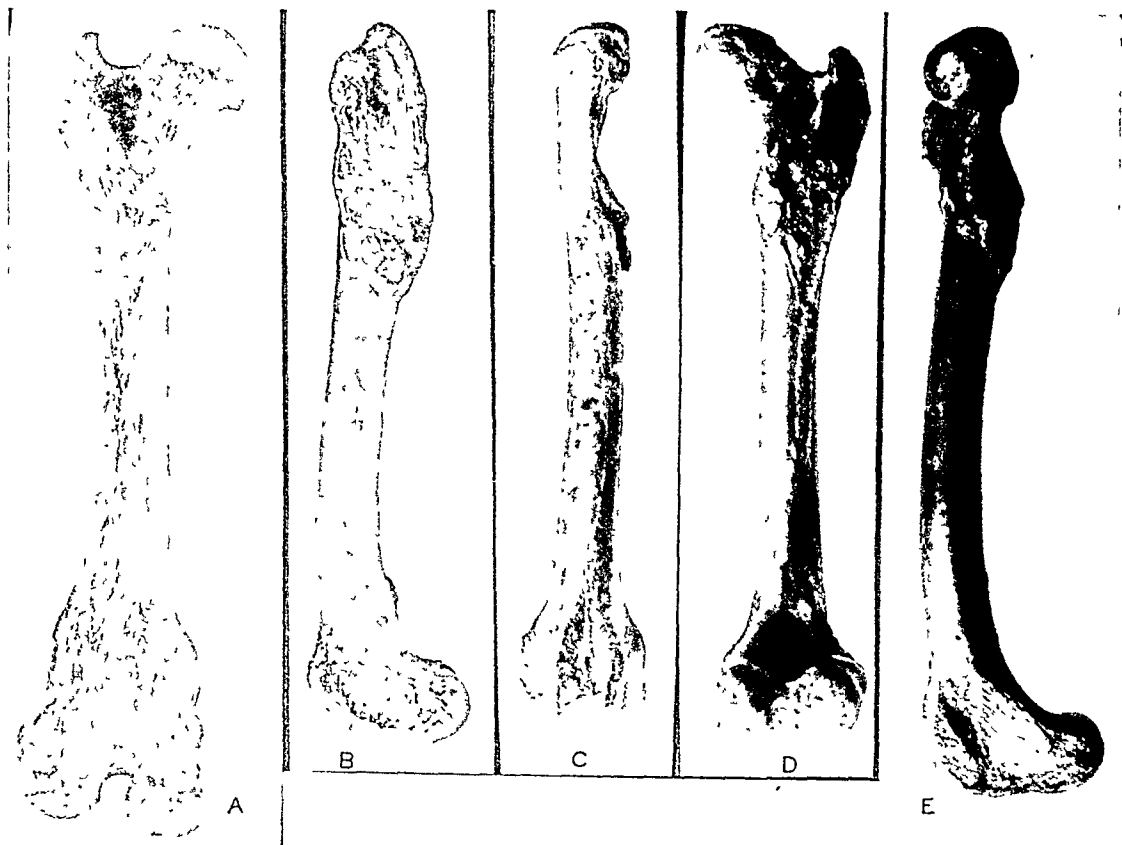


FIG. 2. Wolf femora showing examples of luxations. Pleistocene of the Rancho la Brea. All specimens in the Los Angeles Museum.

A = Small wolf femur, 210 mm. in length, with angle of torsion of  $7.5^\circ$ , showing changes in form of head resulting from fracture in lower one-third. The shaft is unusually short and straight. Another femur, 270 mm. in length, longest femur in collection, is uninjured, but shows angle of torsion of only  $2.5^\circ$ . It is not certain that the short femur shown in "A" is of same species as others figured, it being impossible to tell the effect the injury has had on the growth of bone.

B = Right femur of giant wolf, *Aenocyon dirus*, an extremely rare condition, visceral aspect, showing deforming effect of articulation in absence of *C put femoris*. Length of femur 230 mm., angle of torsion cannot be determined. Compare with kangaroo femora shown in Fig. 5.

C = Same bone, anterior aspect.

D = Right femur of giant wolf, *Aenocyon dirus*, showing deforming effect of acquired luxation due to violence. Lower portion of articulating surface is eburnated. Its extent on to shaft of femur may be judged from "E." The length of the bone is 256 mm., with a degree of torsion of  $8+^\circ$ . The pelvis shown in Fig. 3 is definitely ascertained to belong with this femur, although it was found isolated. It matches perfectly. It is clear that the head of the femur was completely dislocated from the acetabulum and formed a false joint. The luxation was intracapsular. The *Linea aspera* is extensive, doubtless in response to the luxation.

E = Same femur shown from inner aspect. Inferior articular surfaces are not seriously affected.

San Diego Museum, in an attempt to determine the factors underlying luxation. I examined, individually, 1945 femora of the sabre-tooth tiger, as well as all other limb bones of this species, including the metapodials, to the number of many thousands so that the accompanying ac-

and every care has been taken to diagnose the lesions in an open-minded way.

#### REVIEW OF LITERATURE

There does not exist in the literature of paleontology, which I have seen, any discussion of Pleistocene or earlier luxa-

tions. Baudouin (1907) after an extensive outline of congenital luxations gives an account of four Neolithic femora which

pre-Columbian luxation from southern Patagonia in which the acetabulum is completely destroyed and a new articular

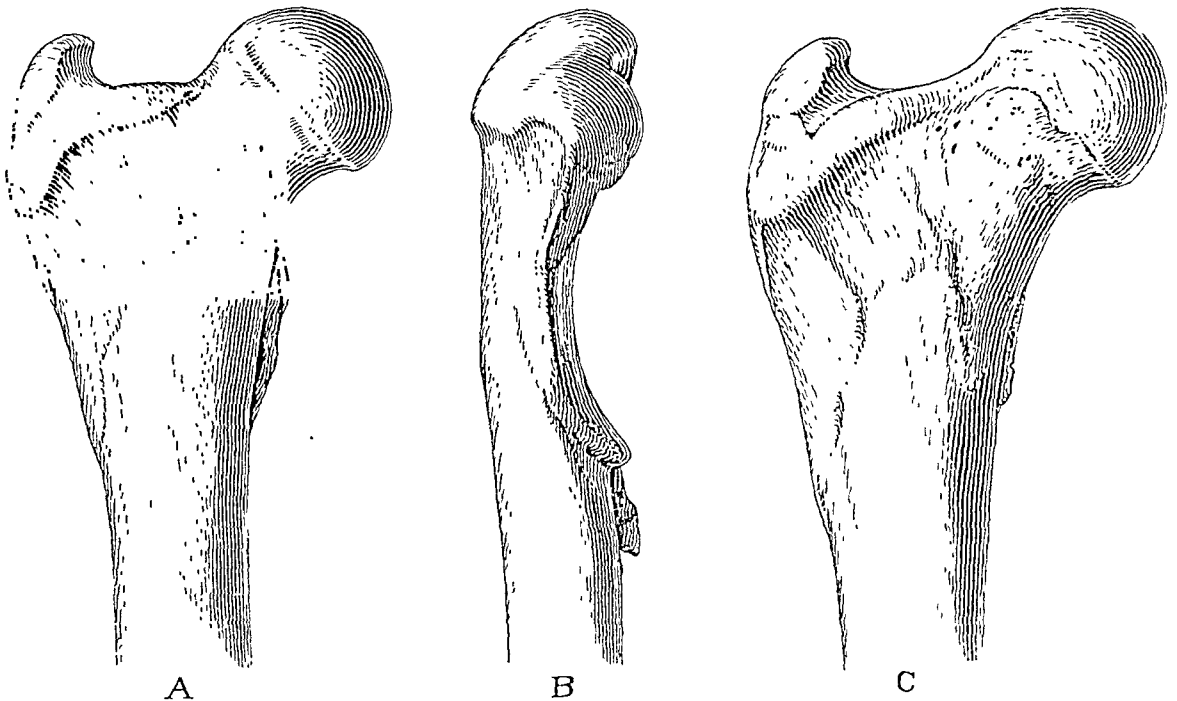


FIG. 3. Right femora of giant wolf, showing different forms of head in A and C in normal bones, and in B articular part of femur showing luxation. Femur in "C" is 270 mm. in length with angle of torsion of  $5^{\circ}$ . All three femora believed to represent *Aenocyon dirus*.

he thinks belong with this type of dislocation. Changes in the heads of the femora lead the author to this classification, but he does not clearly differentiate from the similar conditions following prolonged sepsis.

Fox has described one example of acquired luxation in a captive wild mammal but does not discuss the bone changes.

Job's paper (1891) is of importance. After a review of the literature and a discussion of Broca's tropometre, he describes a new instrument, the trepsimetre, for the determination of torsion. The normal human femur has an average degree of torsion of  $12^{\circ}$ , a maximum of  $25^{\circ}$  and a minimum of  $3^{\circ}$ . Short femora have a greater angle than long; the left more than the right. Pathological femora (fractures, osteomyelitis and genu valgum) are subject to luxation. A femur with an osteomyelitis has a torsion angle of  $49^{\circ}$ .

Verneau (1903) describes and figures a

area extending vertically in a wide trough about two-thirds the length of the pelvis. There is no evidence of eburnation. The femur is not described.

A pre-Columbian pelvis from Peru showing arthritic changes due to luxation is in the Peabody Museum of Anthropology at Harvard University.

#### TYPES OF LUXATIONS SEEN IN PLEISTOCENE MAMMALS

There are, of course, two general types of luxations to consider, and into these groups certain of my specimens naturally fall. Examples of congenital luxation are entirely unknown among vertebrates other than man. Baudouin (1907) speaks of the condition as the "Maladie anthropologique par excellence!" When I first came to the Los Angeles Museum several years ago the first thing to attract my attention was the wolf femur shown in Figure 2, B and C, and the thought that flashed into my mind was *congenital luxation!*

I held this opinion for some years and it seemed to be confirmed by conditions in an adult kangaroo but subsequent study

the pelvis accompanying the wolf femur was made through the Los Angeles collections without success.



FIG. 4. Fragmentary right pelvis of giant wolf which is exactly matched with femur shown in Fig. 1, D and E. The fragment is 159 mm. in length. The acetabulum is almost obliterated, and the functional, new, articular surface is extensively eburnated, with considerable hyperostosis.

brought another interpretation as outlined later. The absence of a *Caput femoris* has another explanation. A special search for

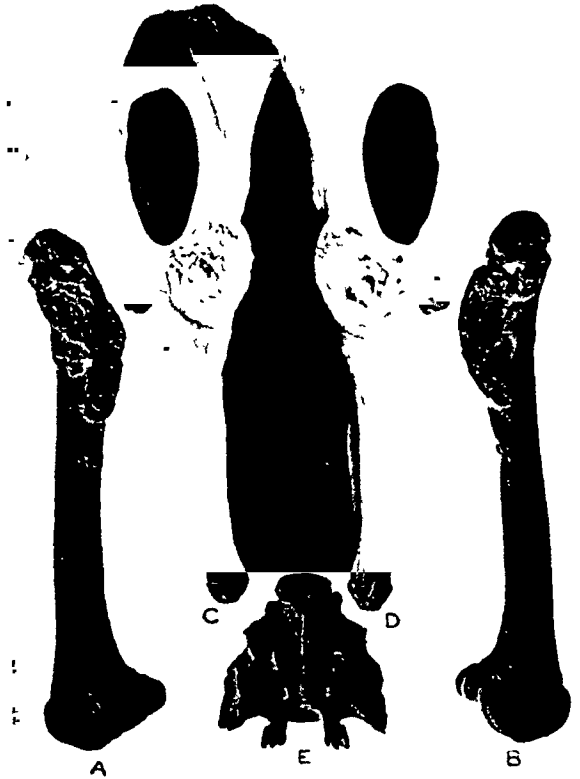


FIG. 5. Femora, pelvis and sacrum of a recent kangaroo, which in life had acquired considerable reputation as a "boxing kangaroo" in one of the Los Angeles Zoological Gardens. Skeleton in Los Angeles Museum.

A = Right femur showing effect of (congenital?) luxation and consequent lack of *Caput femoris* in producing new articular surface with associated surface on pelvis. Length of femur 248 mm.

B = Left femur.

C and D = Right and left pelvis, with greatly modified acetabulum, and eburnation of new articular surfaces.

E = Sacrum.

Acquired luxations are those due to injury after or during birth, to disease, to an exaggerated degree of torsion of the shaft of the femur or humerus; thus rendering luxations easier to acquire, or to a combination of two or more factors. I shall describe an example of luxation due to violence in a giant wolf in which I have the good fortune to possess both the pelvis and the femur (Fig. 2, D and E and Fig. 4). A most interesting example of an acquired luxation is seen in the pelvis of a

sabre-tooth (Fig. 9). There are numerous examples of partial luxations accompanied by more or less extensive arthritic lesions.

acquired luxation following a chronic infection (osteomyelitis?) of the hip. Traces of infection in the wolf femur and in the



FIG. 6. Articulating areas in hip-joint of kangaroo.

A = Arrangement of trabeculae in head of femur.

B = Same in acetabular area of pelvis.

A few of these will be described in this place.

#### BONE CHANGES IN A MODERN, HUMAN, SEPTIC HIP

The search for human examples showing loss of head and neck of the femora, with which to compare our Pleistocene wolf (Fig. 2, B and c) and the kangaroo (Fig. 5), resulted in the acquisition of the roentgenogram by Dr. Todd, shown in Figure 8, based on a septic hip in a young girl at Cleveland. An examination of the femoral head on the right of the picture shows loss of head and neck, and a pushing up of the femur so that the articulation with the pelvis is on the upper part of the femoral diaphysis, exactly as is to be seen in the wolf and kangaroo mentioned previously.

This is not congenital luxation, but an

kangaroo femora and acetabula are elsewhere noted, and it is probably safe to state that the Pleistocene wolf femur (Fig. 2, B and c.), the kangaroo hip (Fig. 5) and the modern child (Fig. 8), are all to be assigned to a similar cause, chronic infection of an unknown type.

An examination of the roentgenograms of children's hips given by Rotch (1910) sheds some light on the present conditions, though none are so clearly paralleled as the case shown in Figure 8.

#### COMPARISONS OF PLEISTOCENE WOLF FEMUR WITH HUMAN BONE

The wolf femur (Fig. 2, B and c) may be regarded as of the same type of change as that shown in the child's hip (Fig. 8), as well as that of the kangaroo (Fig. 5). These three examples, human, wolf and



kangaroo, all show loss of head and neck with almost the same gross features in all.

The femur (Fig. 2, B and C; Fig. 3, B) is



FIG. 7. Undetermined fragment of bone, possibly a portion of femur of giant wolf (*Aenocyon dirus*), showing false joint, a pseudarthrosis, with some excess callus. It has not been possible to associate this interesting fragment with any other bone in the collection. It indicates an ankylosed hip-joint with pseudarthrosis in upper one-third of femur. Pleistocene of the Rancho la Brea, specimen in Los Angeles Museum at Exposition Park. X-ray by Dr. L. C. Kinney.

unique, and the large collections from the Rancho la Brea show nothing similar. A special search was made through the collections for the pelvis belonging with this femur without success.

The articular area of the bone (Fig. 2, B) measures 30 mm. x 75 mm., and articulation seems to have been restricted to the lower part of the area. There is no eburnation of any part of this area, but there is some excess callus at the lower part.

I am unable to explain the deep pit at the top of the area. There are several of them in the kangaroo femora (Fig. 5). It may be a necrotic sinus, though there is now little evidence of a severe infection.

The lower articular surfaces of the wolf femur are not affected, nor are those of the kangaroo.

We are fairly safe in asserting that the loss of the head and neck in the fossil wolf, the kangaroo and the child was due to the same cause in all, sepsis. The nature of the sepsis in the Pleistocene example cannot be determined.

#### FEMORAL TORSION CONSIDERED AS A FACTOR IN LUXATION

It is a recognized fact that in the human femur there is normally about  $10^{\circ}$  to  $12^{\circ}$  anteversion of the head from torsion of the bone, and in a very large percentage of cases of congenital dislocation of the hip it exists to a much more marked degree, even as much as  $90^{\circ}$ , so that it is believed that in the cases of marked torsion deformity, the deformity is the cause of the dislocation, and that probably the dislocation did not occur until after birth from use of the deformed bone.

Job found torsional angles in human femora from  $3^{\circ}$  to  $25^{\circ}$  which had no marked influence on luxation.

In the twelve wolf femora studied by Dr. Ingalls the angles were found to vary between  $1^{\circ}$  and  $13.5^{\circ}$ . This series may be changed by a study of a larger series of bones, but the twelve were especially selected from several hundred.

The method employed in determining the torsional angle in the wolf femora is essentially the same as that employed for a study of human femora. The axis of the head and neck and the center of the head were determined by a Koordinatenzirkel. The long arms of the instrument were both in contact with the head at its greatest diameter and at the same time parallel with what has been considered the neck of the femur for present purposes. This concerns the outline of the neck as seen from above but only that portion on the same level as the head. The lower, flaring part, running down to the lesser trochanter has been disregarded. The neck in the wolf femora is so different from the human condition that it was not possible to determine its midpoint by any direct measurement. The great

trochanter was also left out of account so what was considered as neck is that portion of the bone from 1 to 1.5 cm. in extent,

perpendicular to the long axis of the bone, but this is of no consequence since the angle of obliquity is small.



FIG 8 Pelvis of a white girl between seven and nine years of age. Her history is one of perfect ability in walking until between two and three years ago (November 23, 1927), when she developed an abscess of left hip and was in bed for several months. Thereafter she had a marked limp. She had all of the symptoms of acute inflammation of hip-joint. It is clear that there is complete absence of head and neck (right), without interference, at the epiphyseal line of the great trochanter. Picture from Dr. T. Wingate Todd.

immediately lateral to the head, as seen from above, is the long axis of the bone.

The short middle arm of the Koordinatenzirkel, set at one half the anterior-posterior diameter of the head, marked the center of the head when the long arms were parallel with the axis of the head and neck. The placing of the arms parallel with the axis is purely a matter of judgment or appreciation and involves naturally the estimation of the desired axis and then the placing of the caliper arms parallel to this. The angle determined, the torsion angle, is the angle formed by a line or plane joining the determined points and the retrocondylar plane, which is tangent to the condyles and the trochanteric region. The plane in which the torsion angle lies is

Judging from a comparison of the angle of torsion of the wolf femora with those found in human femora it is concluded that the angle in the Pleistocene wolf is too small to have been of any significance in producing luxations.

TABLE I  
A LIST OF WOLF (*AENOCYON DIRUS*) FEMORA SHOWING  
VARIOUS DEGREES OF TORSION

	Length (Mm.)	Torsion (Degrees)
1. Normal right	225	6
2. Luxated right	256	8+
3. Normal right	271	11
4. Normal left	253	10-
5. Normal right	238	6+
6. Normal right	242	9
7. Normal left	258	5+
8. Normal left	238	1-
9. Normal right	270	2 5-
10. Fractured left	210	7 5
11. Normal right	235	7 5+
12. Normal left	254	13 5



FIG. 9. Right ramus of an adult sabre-tooth tiger (*Smilodon californicus*) Pleistocene, Rancho la Brea, showing lateral surface, extensively diseased. Luxation incomplete, and eburnated articular surface used is shown on left of acetabular area. The extensive pathological growths are without parallel in the field of Paleopathology. They are regarded as due to severe bacterial infection following injury which produced the luxation. What kind of injury effected these changes is unknown, but it was severe. Nearly 2000 femora of the sabre-tooth were examined in an attempt to find the bone which belonged with this pelvis, without success. Doubtless a discharging abscess poured out pus for a considerable period of time, and probably had not healed at the time of the death of the animal. The opening in the floor of the acetabulum is, in part, accidental. The bone was extremely thin and was fractured in collecting. Pelves and sacrum seldom associated in sabre-tooth remains. Only in pathological cases involving the sacroiliac joint are associated parts retained. Pelvis is shown from another angle in Fig. 1. Specimen in the Los Angeles Museum at Exposition Park.

## TRAUMA AS AN IMPORTANT FACTOR IN LUXATIONS

I believe injuries, often of a violent nature, to have been the most important and underlying factor in all of the Pleistocene luxations discussed in this paper. The presence, almost uniformly, of eburnated surfaces in Pleistocene luxations, is an indication that the membrane of the joint has been disturbed by external violence. Trauma underlies all of the dislocations, both partial and complete. In the case of the tiger pelvis (Fig. 9) the violence was followed by a severe infection, which involved not only the hip-joint but all the surrounding areas. The life these mammals led in those far-off Pleistocene days was one of rapine and constant alertness was necessary to avoid injury and death. The wonder is that more luxations are not seen, but an animal with a crippling luxation would be severely handicapped.

## MODERN, BILATERAL LUXATIONS IN A KANGAROO

A skeleton of an adult kangaroo in the Los Angeles Museum shows in the femora and pelvis disturbances which may have followed from sepsis. The animal was said to have been captured in Australia as an adult, and became an inmate of one of the zoological gardens of the city. There is no clinical history and we know only the end-results in the skeleton. No other parts of the body show any pathological changes.

Both hips show exaggerated luxations with loss of heads and necks of the femora (Fig. 5, A and B). The conditions are quite similar to that described for the wolf (Fig. 2B and C). The articular area measures 25 mm.  $\times$  70 mm. and unlike the wolf shows an area near the middle of intense eburnation. The ivory-like bone is more extensive on the pelvis, where the acetabulum has been filled with excess callus. Numerous openings in both femora and pelvis doubtless are necrotic sinuses. The acetabular area measures 43 mm.  $\times$  50 mm., fully one-half of which is eburnated.

Roentgenograms of a femora and the

acetabular part of the pelvis are shown in Figure 6, A and B. The architecture is clearly distorted, showing a condition of long-standing.

There are no changes in the articular surfaces of the lower ends of the femora.

## A PLEISTOCENE PSEUDARTHROSIS

The identification of the fragment of bone shown in Figure 7 is in considerable doubt. I believe it to be a part of the femur of a giant wolf, but it is so changed by the excess callus on which the new articular surface was developed that I cannot be sure. A short time ago I identified as a wolf femur a fragment of a sabre-tooth rib which was so greatly changed by disease as to be almost impossible to identify.

This example of a pseudarthrosis is unique among the Pleistocene mammalia of the Rancho la Brea. Its description in this place is justified because its condition indicates an ankylosed hip. The length of the fragment is 120 mm. with a thickness of 58 mm. through the callus. The diameter of the shaft is 20 mm.

The upper surface of the callus (Fig. 7) is greatly eburnated, though not so highly polished as other eburnated surfaces I have seen. The eburnated area is saddle-shaped, measuring 30 mm.  $\times$  35 mm. Around its edges roughened bone suggests an intense preceding infection. I believe the bone to have been fractured immediately below the anatomical neck, but extracapsular.

The roentgenogram shows the bone immediately below the eburnated area to be quite dense.

## A TRAUMATIC LUXATION

The wolf femur (Fig. 2, D and E) showing the effects of a traumatic dislocation is complete, measuring 256 mm. Careful measurements of several hundred femora of *Aenocyon* show ranges in length of from 230 mm. to 270 mm., so the present example is a little above the average. The torsional angle is  $8^{\circ}$ .

There is no way of explaining just how

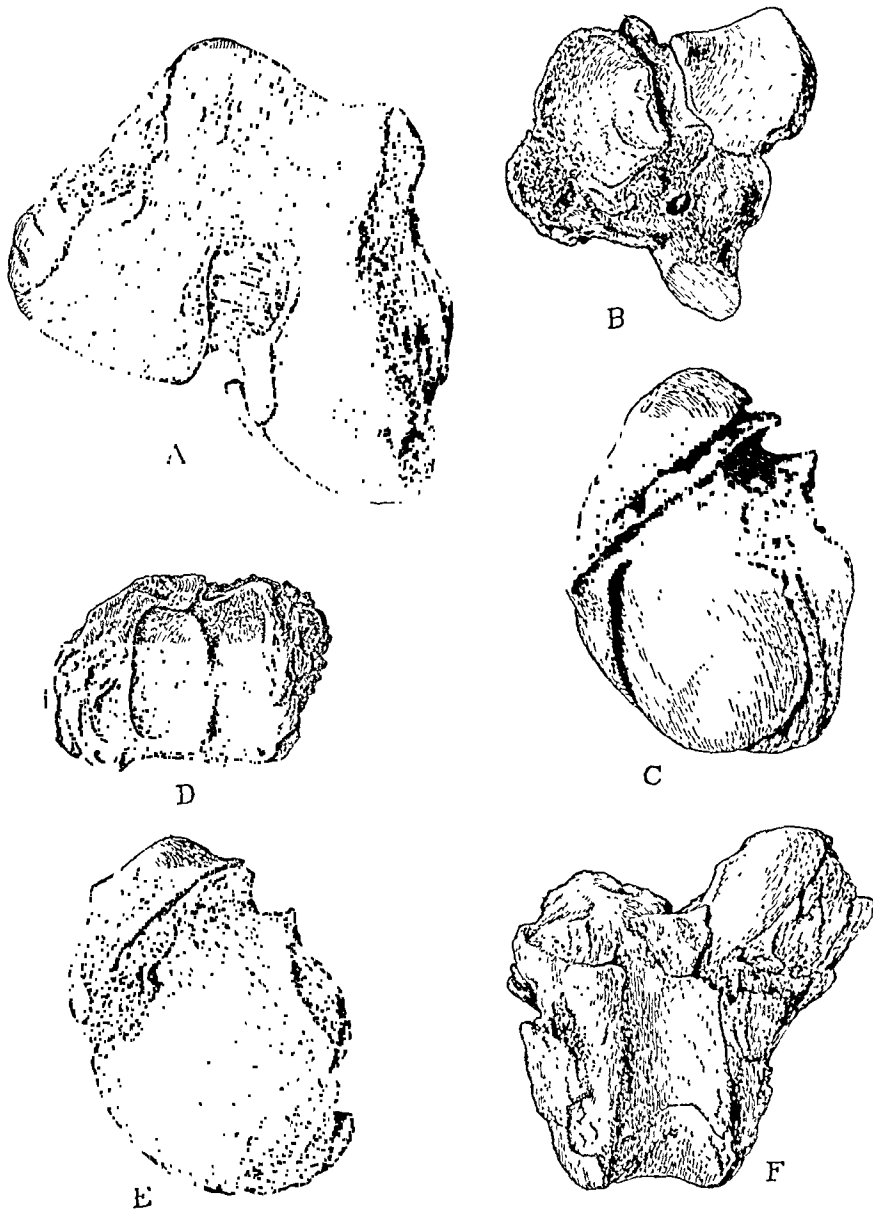


FIG. 10. A: Lower articular surface of right femur of *Smilodon californicus*, Pleistocene sabre-tooth from the Rancho la Brea, showing reduction of articular area by peripheral exostoses. Posteriorly articulating surfaces are eburnated for distance of 50 mm. Area here shown had not been in use for some time before the death of the animal thus forming an example of partial or incomplete luxation. Marginal lipping, posteriorly, more pronounced on right side of the bone and associated with disturbance in the popliteal space, above which on the right there is a large exostosis. Greatest diameter of surface depicted 85 mm.

B: Upper articular surface of tibia of giant wolf, *Aenocyon dirus*, showing arthritic disturbances involved in partial luxation. Peripheral lipping more pronounced on left in drawing due to injury represented by the large exostosis. Area shown has diameter of 52 mm.

C: Upper articular surface of humerus of giant wolf showing almost complete luxation brought about by extravagant growth of periartritic lesions. Lips of bicipital groove ossified for considerable distance down anterior surface. Oval area, shown in drawing, had been the only functioning articular surface for some time. Area is eburnated and worn almost flat. Associated scapula has been identified, and is shown in Fig. 11, upper figure. Oval area has long diameter of 30 mm.

D: Lower articular surfaces of pathologically coossified tibia and fibula of giant wolf. Joint highly diseased and articulating surfaces deepened, eburnated and worn. Transverse diameter of surface shown is 54 mm.

E: Upper articular surface of humerus of giant wolf which had been fractured and in which severe osteomyelitis had developed (see *Ann. M. Hist.*, 8: 416, 1926). Disturbances in articulation due to necessity brought about by newly established angle of torsion. Area is restricted, eburnated and imperfect, a partial luxation. Entire bone much shortened, having length of 180 mm., as compared with a length of 227 mm. of normal bone.

F: Lower articular surface of incomplete femur of giant wolf. Partial luxation indicated by destruction of condyle on the left. Surface on right was only one functioning and that was rendered imperfect by arthritic lesions which had crept in from the sides. Numerous lesions about and above joint surface indicate an intense infection due to injury which involved destruction of condyle. Joint surface very imperfect.



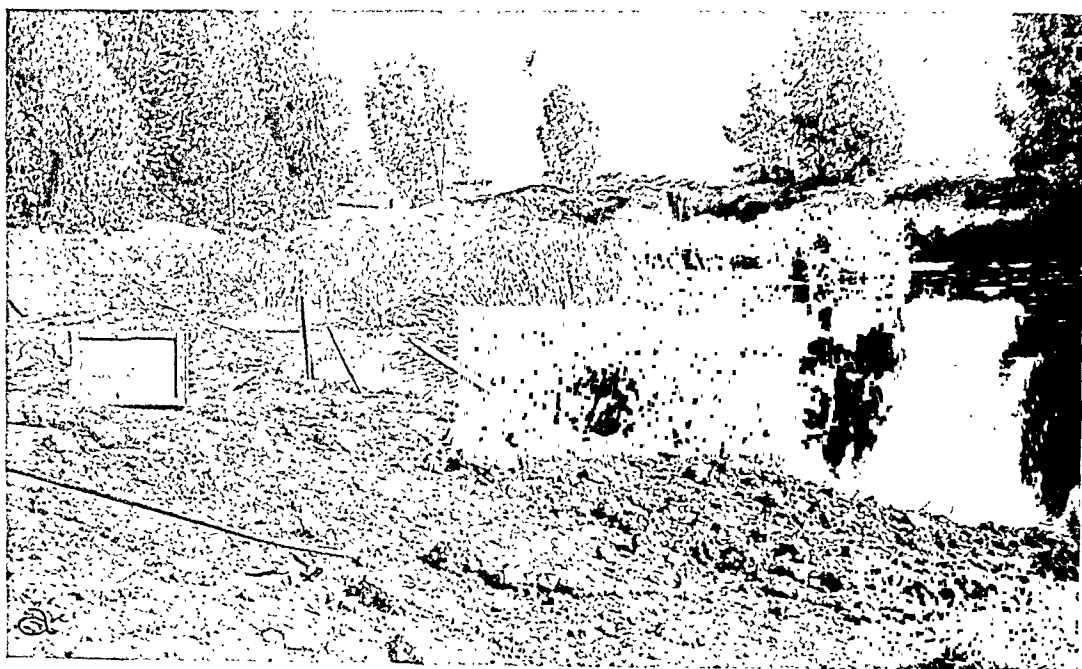


FIG. 12. Large pool or pit at the Rancho la Brea on Wilshire Boulevard, Los Angeles, as it appeared twenty years ago. It has not changed perceptibly since. This pit made originally for asphalt for road building and bones of Pleistocene mammals were cast aside. Further excavations subsequent to 1906 resulted in recovery of much material. When I visited the locality in 1909 elephant bones were being extracted from bank to right of *b*. The entire area, something over 30 acres, has been given by the owners to the county as a Pleistocene Park, under the direction of the Los Angeles Museum.

*a*: Water and oil cover floor of pit to undetermined depth. Gas bubbles may be seen breaking surface in background on right.

*b*: Asphalt seen at east end of pit. Tar fairly soft and viscid. It forms a most wonderful trap for unwary animals, giving an insight as to how Pleistocene mammals were caught.

4) of a giant wolf which definitely match, though found separate.

As shown in Figure 4 the acetabulum is



FIG. 13. Left ramus, adult sabre-tooth pelvis, Rancho la Brea, showing great roughening and thickening in area about acetabulum, due to infected injury, and resulting in partial luxation of hip. Normal acetabulum practically circular, measuring about 50 mm. in diameter, but this acetabulum has area of 55 mm. x 70 mm., and is quite shallow, while normal acetabulum is quite deep. Upper (to right) one-half of articular area functional, and highly eburnated, with maximum diameter of 30 mm.

Entire length of pelvic ramus 30.5 cm. Los Angeles Museum of History, Science and Art, Exposition Park.

completely destroyed and filled in with excess callus. On this excess callus is an eburnated area, 25 mm. x 45 mm., saddle-shaped, on which the neck of the femur (Fig. 2, D and E) articulated. As in the case of the pseudarthrosis (see Fig. 7) the margins of the eburnated area are beset with greatly roughened bone. The head of the femur also shows changes.

The pelvis (Fig. 4) is fragmentary, measuring 160 mm., as compared with a measurement of 225 mm. for the complete bone.

Another example of complete luxation is to be found in the pelvic bone of the giant wolf in which the acetabulum is reduced

from the normal by 3 mm. in diameter, with an enormous amount of callus, roughened by numerous exostoses and

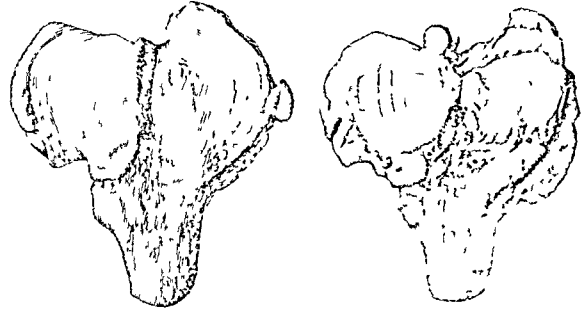


FIG. 14. Luxation in tibia of a coyote, Rancho la Brea.

Left: Articular area only slightly reduced by marginal osteophytic growths. x 1.

Right: Right tibia of Pleistocene coyote, Rancho la Brea. Articular surfaces greatly reduced, to area of 10 mm. on one side, to the right, and to area of 7 mm. on the other. This small area highly eburnated with series of parallel striae. Marginal osteophytes very pronounced, indicating arthritic disturbance of some severity. x 1. Los Angeles Museum of History, Science and Art, Exposition Park.

necrotic sinuses. The acetabulum shows no sign of wear, and an area on the upper side measuring 15 x 42 mm. shows eburnation as if the neck of the femur had articulated on this surface, in this case leaving the acetabulum without much change.

#### AN UNUSUAL PATHOLOGICAL CONDITION

The following is an unusual pathological condition in the pelvis of a sabre-tooth regarded as due to infection, following a violent trauma, which also resulted in luxation.

The sabre-tooth pelvis, shown in Figures 1 and 9, is the most strikingly pathological object in the collection of Rancho la Brea fossils, preserved in the Los Angeles Museum. The infection, following trauma, confined its ravages to the right pelvic ramus. The acetabulum of the diseased side measures 85 mm. in diameter, as compared with a diameter of 48 mm. in the normal side (see Fig. 1).

The pelvis is probably that of an adult male, and the injury may have been received in an encounter with another sabre-tooth. The entire acetabular region resembles in its appearance that of a lava bed. The several vesicular pockets, measuring 17 mm. in depth and 36 mm. in



length, recall black lava bubbles. The numerous osteophytic growths are largely rounded near the acetabulum, but out on the ilium they are fenestrated and spinous. The articular surface for the head of the femur is restricted to an eburnated area in the dorsal portion of the acetabulum (Fig. 9). The bone forming the bottom of the acetabulum is of paper-like thinness, and although broken in the specimen during collection, it was doubtless complete during the life of the animal. The dorsal aspect of the acetabular region presents a thickness of 44 mm. as compared with 28 mm. of the normal side. This surface is covered with ramifying vascular channels and foramina, recalling in appearance the surface features of an osteosarcoma in an ancient Egyptian pelvis, described by Ruffer. Like that specimen, too, the tiger pelvis presents a pubic thickness which may well represent a tumor, but I think from the general aspect of the bones that all of lesions were due to infection, following trauma, and are not neoplastic.

The pelvis was isolated and no associated bones, such as the sacrum and femur, have been identified in the collections. Although I have examined individually all of the 1945 femora of the sabre-tooth,

contained in sixty museum trays, during a count to determine the incidence of disease (1.64 per cent) I found no trace of a femur showing characters such as would be demanded by the articulation with this disturbed acetabulum. The femora present evidences of fracture,<sup>1</sup> pressure atrophy,<sup>1</sup> arthritis deformans,<sup>3</sup> slight subperiosteal exostoses,<sup>10</sup> and partial luxation of the lower end,<sup>1</sup> but not an upper luxation. I made no effort to try to match any of the 1046 sacra with this pelvis.

A luxation in a tiger pelvis, without infection, is shown in Figure 13. The acetabulum is extremely shallow and the luxation seems to have been of long standing.

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## BOOK REVIEWS

**RADIOGRAPHIE NEPHRO-CHOLECYSTIQUE.**  
By Dr. Manuel de Abreu, Brazilian Inst. of Sciences & Acad. of Med. Rio de Janeiro. 158 pp. 54 cuts, & 54 drawings. Paris, Masson & Cie, 1930.

The reader finds this a very interesting work on the radiographic diagnosis of gall-bladder and renal disease, especially with reference to the differential diagnosis. The differential diagnosis of abdominal concretions is often complicated, particularly gall-bladder and renal calculi. The author has studied very carefully

the various angles of incidence, anterior, posterior, oblique and combined; and has estimated the volume and shape of the kidney in these various positions. He has made a careful comparison of vesicular and renal shadows, especially after turning the patient in the oblique position so that the zone of the renal pelvis is thrown far away from the shadow of the gall-bladder region. The author calls attention to the advantage of pyelography in the Trendelenburg position, the renal pelvis and the calyces being demonstrated more easily in this position, and recommends renal

radiography in the oblique incidence when there is doubt as to the findings in the classical anteroposterior position. The value of the book is greatly enhanced by the beautiful collection of roentgenograms.

ETUDES RADIOLOGIQUES SUR LE POU MON  
ET LE MEDIASTIN, RADIOLOGIE VASCU-  
LAIRE—AORTE. [Radiological Studies of  
the Lung and Mediastinum, Vascular  
and Aortic Radiology.] By Manuel  
de Abreu, Brazilian Inst. Sciences &  
Acad. of Med., Rio de Janerio. 200 pp.  
42 tables, 79 figs. Paris, Masson, 1930.

This work is characterized by the originality of the author's views and the interest one must take in his personal researches concerning the aorta and the heart. Considerable discussion has been aroused in France by the publications of Dr. Abreu, and it is gratifying to see this abundantly illustrated publication setting forth his latest views.

The first chapter concerns the evaluation of the relative volume of pulmonary lesions; the second chapter discusses the various discrete forms of pulmonary tuberculosis as seen in the roentgenogram; the third concerns roentgenometry of the mediastinum; and the fourth is a critical discussion and interpretation of the classical findings of vascular radiology, followed by certain new signs which the author has developed.

RADIOLOGIE CLINIQUE DU TUBE DIGESTIF.  
[Clinical Radiology of the Digestive  
Tube.] By J. Gatellier, Assist. Prof.  
Fac. Med. Paris; F. Moutier, Chief, Lab.  
Fac. Med. Paris, and P. Porcher, Chief,

Dept. Radiol. Fac. Med. Paris. Publ.  
under direction of M. Pierre Duval, J. Ch.  
Roux, and Henri Bécclère. Vol. 2, 390 pp.,  
417 roentgenograms & 407 schematic  
drawings. Paris, Masson et Cie, 1930.

The first volume of the series appeared in January, 1928, and in spite of a rather large edition the book soon was out of print. The presentation and the method of explanation of this second volume are identical with that of the first. The same rules that were followed in the volumes on the Stomach and Duodenum have been adhered to rigorously with reference to the execution of the present work. This is not simply an album of choice roentgenograms with simple legends. All of the illustrations have been carefully chosen because of their utility in demonstrating important lesions of clinical radiology, and the text constitutes a running commentary of the facts which justify the diagnosis, illustrated by roentgenograms. Each roentgenogram is accompanied by a carefully made outline drawing, with the indications of the various anatomical points. The book constitutes a valuable collection of diagnoses, carefully discussed and proven, including the pathology of the esophagus, the intestine, the pancreas, the spleen, the liver and the salivary glands. Each of the diagnoses is established both by clinical and radiological evidence, and is confirmed by operative intervention.

The publishers have aided very satisfactorily with the production of the book, which constitutes a volume of which the radiological profession, both in France and in this country, may well be proud.





# A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

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PUBLISHED SERIALY IN

## *The American Journal of Surgery*

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# A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

## SECTION II. THE GASTROINTESTINAL TRACT

### A. BASIC EMBRYOLOGICAL CONSIDERATIONS (*Continued*)\*

#### 4. FINAL ATTACHMENTS OF THE GASTROINTESTINAL TRACT (*Continued*).

c. *Attachments of Stomach.* Peritoneal folds pass from the stomach to the liver, transverse colon, spleen, biliary ducts, diaphragm and pancreas. The structure of these folds is indicated by their several names (gastric ligaments, omenta, epiploa). They are termed ligaments because of the support which they provide (L. *ligamentum*, a band or bandage); omenta, because rich in fats (Gr. *omentum*, a fatty membrane); and epiploa, because compound in character (Gr. *epi*, upon + a double fold). The words epiploic and omental are, then, synonymous (see epiplocele, epiplocephalocoele, epiplopepy). The two broad surfaces of the stomach, an anterior belonging to the general peritoneal cavity and a posterior belonging to the lesser cavity or omental bursa, are free and unattached, for gastric attachments are found only along the curvatures (Fig. 120 A & B). The postnatal stomach, in contrast to the embryological organ, has no direct connections with the abdominal walls but is joined to the parietes only indirectly or by way of intervening viscera. Omenta are, in fact, defined as compound peritoneal folds which pass from the stomach to other intra-abdominal organs. This final arrangement represents a marked change from the earliest conditions in which the developing stomach is attached to the anterior abdominal wall by an anterior mesentery and to the posterior wall by a posterior mesentery.

Terminology

\* Previous installments of this book appeared as follows: vol. 8, January issue, p. 193; February issue, p. 459; March issue, p. 693; April issue, p. 92; May issue, p. 1110; June issue, p. 1325; vol. 9, July issue, p. 157.

All ligaments and omenta of the adult stomach originate, however, from the simple midline mesenteries of embryonic life Fig. 121. And the logical manner in which to gain a clear

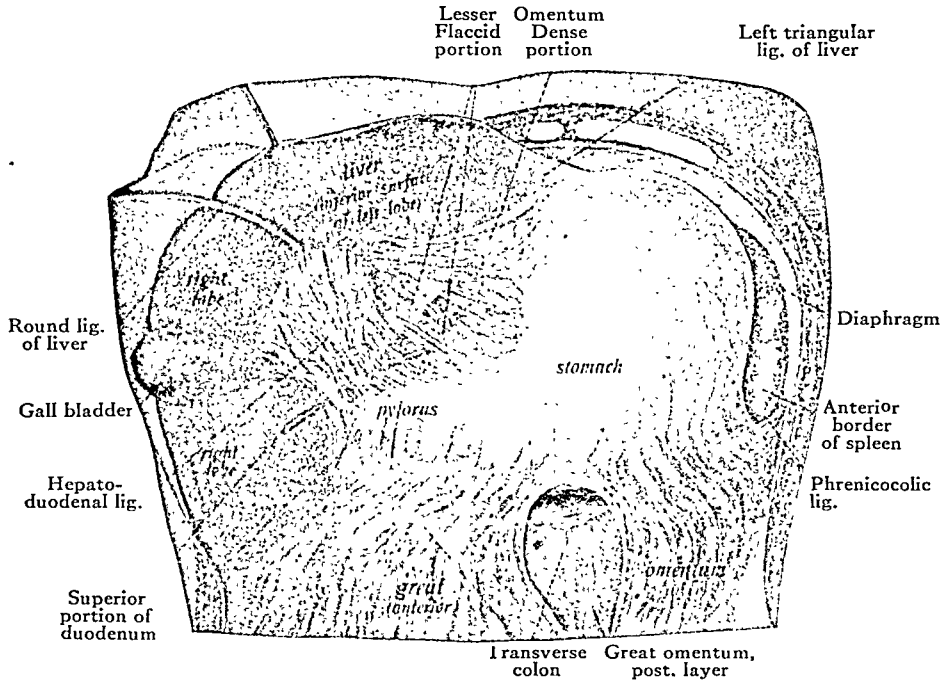


FIG. 120A. Attachments of the stomach.

A. Anterior view. (From Sobotta).

comprehension of the ultimate, complex connections of this organ is through a visualization of succeeding steps or stages in gastric development.

The manner in which stomach becomes connected with liver is as follows: the bulk of the liver (mesodermal portion) develops within the anterior mesentery (see septum transversum and its derivatives; p. 17); hence this large digestive gland becomes interposed between stomach and anterior abdominal wall so that the stomach no longer appears connected with parietes but with liver (See Fig. 121). The connecting double peritoneal fold is appropriately termed the *lesser* omentum (ligamentum hepatogastricum) thus reserving the name *greater* omentum for that larger fatty sheet which passes between stomach and transverse colon (ligamentum

Origin of Lesser  
Omentum

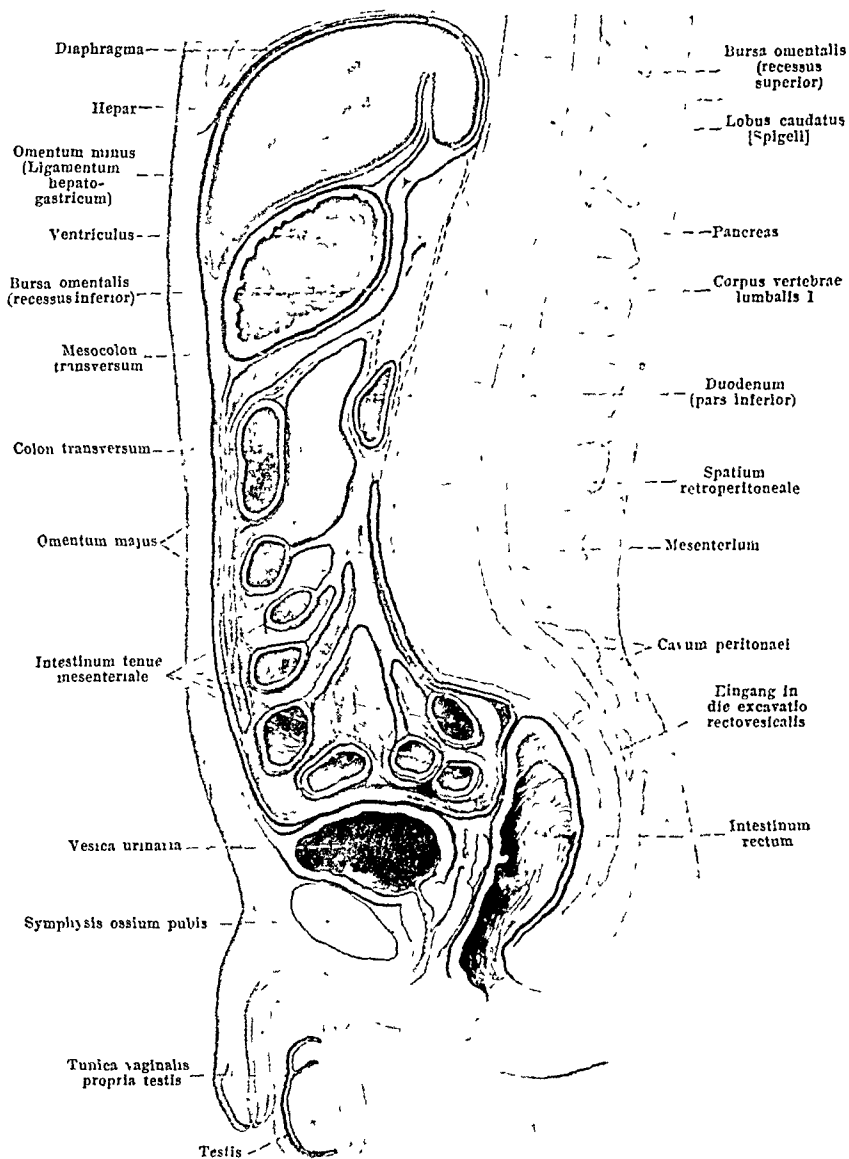


FIG. 120B. Attachments of the stomach.  
B. Longitudinal section. (From Spalteholz.)

gastrocolicum) then continues downward in front of the intestinal loops as a large caul, veil or apron. The gastrohepatic or lesser omentum extends from the entire lesser curvature of the

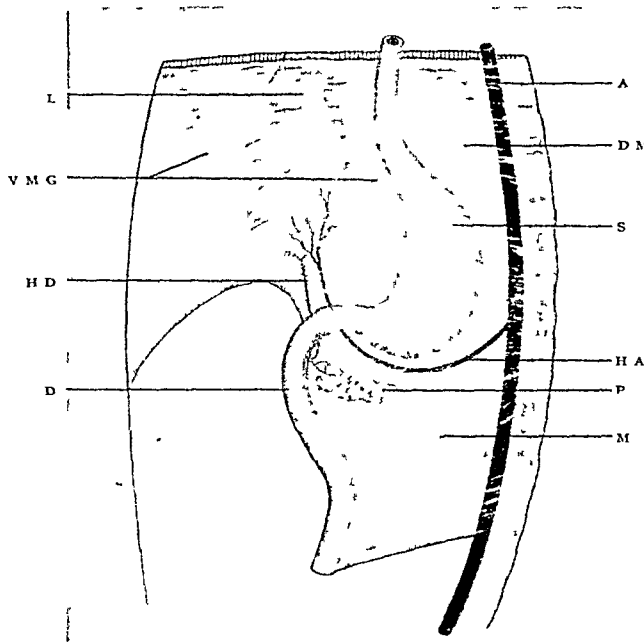


FIG. 121. Simple mesenteries of embryonic stomach. Note: liver develops between stomach and anterior body wall changing attachment of stomach. Observe association of hepatic artery and duct near free border of ventral mesentery. This arrangement is important with reference to the formation of foramen of Winslow. The liver divides the ventral mesogastrium into a dorsal segment, the gastrohepatic or lesser omentum, and a ventral segment, the suspensory or falciform ligament of the liver. (From Huntington.)

L, liver V M G, ventral mesogastrium H D, hepatic duct D, duodenum A, aorta D M dorsal mesogastrium S, stomach H A, hepatic artery P pancreas M mesoduodenum

stomach to the under surface of the liver (transverse fissure or porta hepatis). Specific details regarding its portal attachments will be discussed with the study of the liver (Section IV) and the peritoneal bands known as ligamenta variata (Section V).

As shown by the researches of Winslow (see eponym) the peritoneal coverings of the omenta are continuous with those of the stomach. This investigator, inserting a quill beneath peritoneal surfaces at various points, ascertained their exact reflections by observing the manner in which air he introduced



through the hollow instrument insinuated itself through sub-peritoneal tissues.<sup>155</sup> And the lesser omentum, it was ascertained, like the stomach, possesses two free surfaces, of which

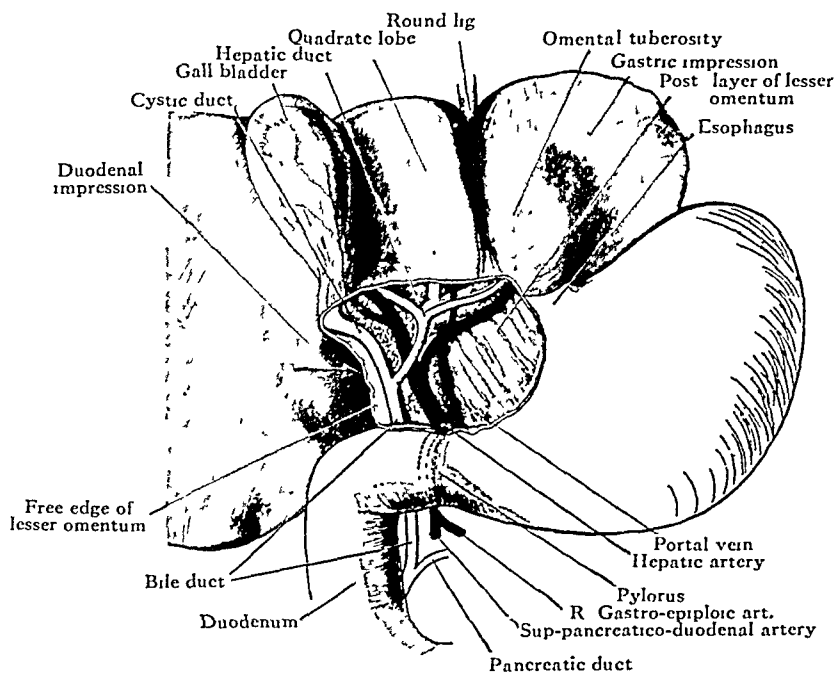


FIG. 122. Structures within right or free border of lesser omentum. (From Cunningham.)

Researches of  
Winslow

one is related to the general peritoneal cavity and the other to the omental bursa (see Fig. 120). Between the omental layers are found fat, vessels, areolar tissue, nerves, lymph nodes (see primary germ layers, p. 281 and intra-abdominal neoplasms, p. 279).

Between the peritoneal reflections a narrow sheet of extra-peritoneal tissue connects stomach and liver (see Fig. 120). Because of this, it is possible for a sharp foreign body to penetrate stomach wall, work its way between the leaves of the lesser or gastrohepatic omentum to reach and penetrate the liver and there set up an inflammatory reaction or give rise to an hepatic abscess, without causing any invasion of the general peritoneal cavity. Treves has thus explained the finding of sharp bones or toothpicks within liver abscesses.<sup>156</sup> A similar

Extraperitoneal  
Pathways

invasion, without concomitant involvement of the general peritoneal cavity, of the extraperitoneal pathways found between the peritoneal surfaces, has previously been noted in describing cases reported by Osler,<sup>157</sup> in which abscesses confined within the falciform ligament of the liver were drained by way of the anterior abdominal wall without a resulting general peritonitis (p. 12). Such unusual cases serve not only to bring to mind these possibilities but also aid materially in effecting the visualization of anatomical relationships.

Within the free margin of the lesser omentum (right border or hepatoduodenal portion) are situated the following important structures, named from right to left; (a), the common bile duct, (b), the portal vein (c), the hepatic artery, (D: V: A; duct: vein: artery) together with lymphatics and nerves. The vein lies posterior to the artery and duct and between them. (Fig. 122, also Fig. 125.) This arrangement has both definite advantages and disadvantages for the surgeon. It is advantageous in that the common bile duct may readily be found and palpated within this free omental border and the common duct; coursing along this extreme free margin, may be incised if necessary, as for the liberation of a common duct stone, without great danger to hepatic artery or portal vein which lie further to the left. It is disadvantageous, however, in cases of herniation through the foramen epiploicum, for the free margin of the lesser omentum forms the anterior boundary of this opening (Winslow's foramen); here herniated bowel may be incarcerated at the orifice, yet the operator be unable to liberate the gut by cutting the most accessible part of the constriction (free border of lesser omentum). Should this right border of the omentum be cut through, the common bile duct would certainly be severed and a risk taken of causing irreparable damage to the hepatic artery or portal vein. This condition in which distended intestinal loops cannot be mechanically withdrawn from the omental bursa into which they have passed, may be dealt with by the method previously described of first incising and emptying the bowel by means of a suction tube

Palpating the  
Common Bile  
Duct

Releasing Bowel  
Herniated through  
the Foramen  
Epiploicum

(Fig. 117). The immediate collapse of the intestinal loops which follows this withdrawal of the enteral contents renders reduction of the internal hernia by simple traction an easy

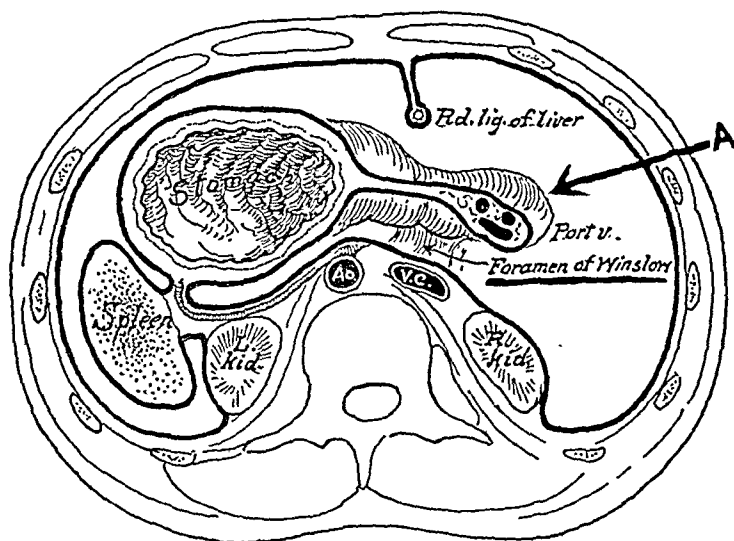


FIG. 123. Cross section of abdomen at level of foramen epiploicum. Note relationship of structures in free border of lesser omentum (A) (duct, vein, artery) to the foramen of Winslow. (From Hertzler's *The Peritoneum*, Mosby.)

and successful maneuver and one which may be accomplished without endangering important structures at the point of obstruction.

The foramen of Winslow (foramen epiploicum), as described in the words of the anatomist in whose honor it is named, is considered in an accompanying eponymic study (pp. 263-267). This important narrow point of constriction within the peritoneal cavity is produced largely by the hepatic artery as it passes upward from its retroperitoneal origin from the celiac axis,<sup>158</sup> taking the shortest course to reach the liver, thereby throwing the overlying peritoneum into an elevation or ridge. The constriction is increased by the portal vein as it courses upward from below the pancreas to reach the liver by way of the lesser omentum. The manner in which artery aids in the formation of the foramen of Winslow, after the stomach has undergone rotation and as the first portion of the duodenum

Origin of the  
Foramen of  
Winslow

has become fixed or partially retroperitoneal, will be reviewed subsequently with a study of the vascular supply of the enteric canal and its derivatives. Suffice it to state that as the artery

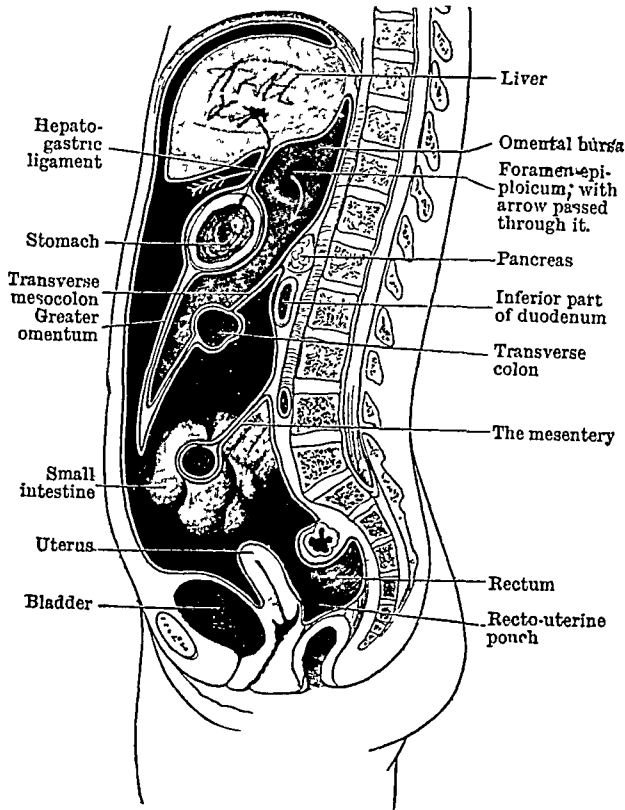


FIG. 124. Omental bursa and foramen of Winslow. Diagrammatic median section of female body, to show the peritoneum on vertical tracing. The great sac of the peritoneum is black and is represented as being much larger than in nature; the bursa omentalis is very darkly shaded; the peritoneum on section is shown as a white line; and a white arrow is passed through the foramen epiploicum from the great sac into the bursa omentalis. (From Cunningham.)

leaves the retroperitoneal tissues to traverse the free border of the lesser omentum and reach the liver at the porta hepatis, the peritoneum is thrown into an hour-glass constriction so tight as to allow only the finger (index) to pass between the artery anteriorly (free margin of lesser omentum) and the posterior abdominal wall posteriorly (parietal peritoneum) (Fig. 123). The foramen represents, in a word, a space or semi-

lunar opening below the margin of the original ventral mesogastrium. It must be apparent that some such foramen or cleft leading into a retrogastric space is an inevitable accompani-



FIG. 125. Foramen of Winslow. The deep relations of the liver and the chief structures in relation to the common bile duct. The right and left hepatic ducts unite to form the hepatic duct proper, and this is joined lower down by the cystic duct, the junction of these two forming the common bile duct. This latter is seen in its supraduodenal stage in front of the foramen of Winslow. (From Taylor's Operative Surgery, Wood.)

ment of the rotation of the stomach and subsequent fixation of the duodenum (the lowest point in the gastrointestinal tract supplied with a ventral mesentery); (see Fig. 121) but it is the hepatic artery, taking the shortest course from its fixed retroperitoneal point near the adherent duodenum to reach the liver by traversing the margin of the gastrohepatic omentum, which determines the fact that the foramen is of such small caliber.

Because of this constriction (foramen epiploicum) the peritoneal cavity seems to consist of two compartments

(greater and lesser sacs) (Fig. 124) whereas in reality the peritoneal membrane forms but a single cavity and this narrow point (foramen of Winslow) is simply a secondary developmental arrangement. To find this foramen the surgeon must invade the supracolic division of the peritoneal cavity, lifting forward the right lobe of the liver and depressing the stomach. The palpating finger is passed along the posterior parietal peritoneum immediately above the proximal or first portion of the duodenum until the finger tip has passed below the free border of the lesser omentum (Fig. 125). The relationship of the examining finger to surrounding structures is then as follows:

Locating and  
Palpating the  
Foramen  
Epiploicum

In front (anteriorly) lies the right border of the lesser or gastrohepatic omentum (ligamentum hepatogastricum) containing, from right to left, the ductus communis choledochus, the portal vein and the hepatic artery.

Behind (posteriorly) lies the inferior vena cava and the right crus of the diaphragm, covered by the posterior parietal layer of peritoneum.

Above (superiorly) is located the caudate lobe of the liver.

Below (inferiorly) is situated the duodenum and the part of the hepatic artery proximal to its entrance into the free margin of the lesser omentum.

The retrogastric space, omental bursa, lesser peritoneal sac, Winslow's pouch and cavity of the omenta, all are terms applied to the cavity existing behind the stomach and reached through the foramen epiploicum just described. This peritoneal pocket with its peculiar narrow point of connection with the remainder of the peritoneal cavity is developed as follows: as the stomach rotates, its dorsal mesogastrium, which originally stretched firmly from the posterior gastric wall (developing greater curvature) to the midline of the posterior abdominal wall, necessarily must become relaxed or elongated to allow the rotation to take place; and when the gastric fundus reaches its final position to the left of the midline it is obvious that a pouch must exist behind this viscus, and that

Formation of the  
Omental Bursa

this pouch must be closed from the general peritoneal cavity above, below and to the left, but open into it on the right side Fig. 126. The omental bursa into which, as stated, the tip of the

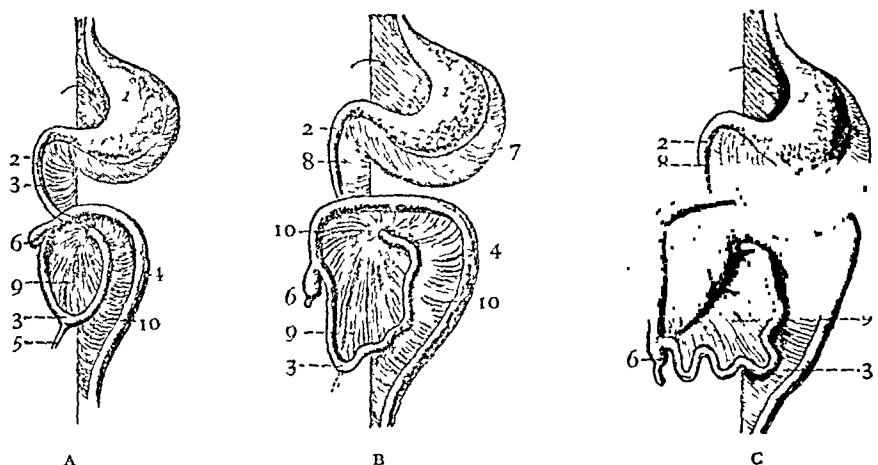


FIG. 126. Formation of omental bursa. Three successive stages, showing the development of the digestive tube and the mesenteries in the human fetus. (Modified from Tournoux.)

1, stomach, 2, duodenum; 3, small intestine; 4, colon; 5, vitelline duct; 6, cecum; 7, great omentum; 8, mesoduodenum; 9, mesentery, 10, mesocolon. Arrow points to the orifice of the omental bursa. The ventral mesentery is not shown (Heisler). (From Prentiss' Textbook of Embryology, Saunders.)

examining finger passes when it is inserted into the foramen of Winslow is in reality a pocketing of the right half of the upper portion of the peritoneal cavity as the stomach undergoes rotation.

Various routes by which the omental bursa may be invaded (by infections, by foreign bodies, by the surgeon) are shown graphically in the accompanying Figure 127 A-C. Surgical drainage (for perforations of the posterior gastric wall, pancreatitis, bullet wounds) has been discussed on p. 152; drainage is most often effected by way of the lesser omentum or through the gastrocolic ligament, less often by way of the transverse mesocolon, and occasionally through the posterior abdominal wall; the latter method is employed only in instances in which a foreign body has invaded the bursa by this pathway (see bullet wounds of stomach and pancreas). Whatever route is chosen for draining this lesser peritoneal sac it seems logical also to place a prophylactic wick or drain into

Contamination and  
Drainage of the  
Retrogastric Space

the subhepatic space (Morison's space) inasmuch as excess fluid from the omental bursa spontaneously invades this region, passing through the foramen of Winslow. With the patient on

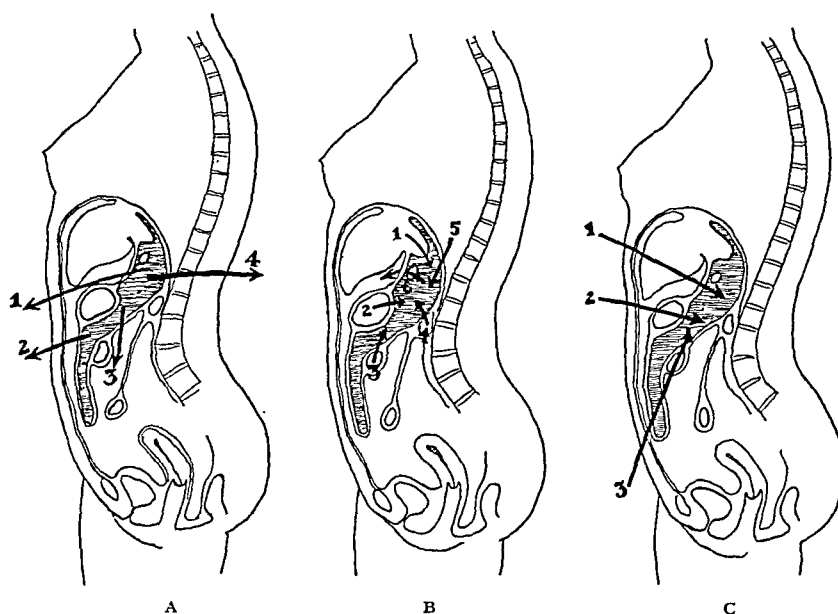


FIG. 127. Approaches to the omental bursa.

A. Surgical drainage: (1) through lesser omentum; (2) through gastro-colic ligament; (3) through transverse mesocolon; (4) through posterior abdominal wall.

B. Direct contaminations (infections): (1) from liver; (2) from stomach; (3) from colon; (4) from pancreas; (5) from thorax; (6) drainage through foramen of Winslow.

C. Gunshot wounds: 1-3 illustrate how penetrating foreign bodies may invade omental bursa after passing through other structures.

the right side this drainage out of the bursa by way of the epiploic foramen is a natural or gravity outflow. Contamination of the subhepatic space seems so inevitable that drainage by other routes alone would appear scarcely complete. A prophylactic wick in the subhepatic space could do little harm and might prove the means of preventing widespread contamination of the general peritoneal cavity.

The elongation and relaxation of the primitive dorsal mesogastrium does not cease with the completion of the rotation of the stomach but continues until a broad sheet of peritoneum (floor of omental bursa) hangs down from the greater curvature of the stomach ventral to the coils of small intestine,



Development of  
Greater Omentum

forming a great quadrupulature of peritoneum (great omentum). This fold (see Fig. 126 c) represents the original dorsal mesogastrium and after passing downward from the greater gastric curvature and being reflected upward again reaches the dorsal wall of the abdomen at a point slightly above the line of attachment of the transverse mesocolon (q.v.). At first attached vertically in the midline, this peritoneal fold, by fusion with the parietal peritoneum later acquires an attachment which is transverse in direction and is thereby brought into contact with the upper layer of the transverse mesocolon. Fusion of the two ultimately results. This brings the floor of the omental bursa into union with the transverse colon and completes the formation of the adult gastrocolic omentum. As demonstrated in accompanying figures the transverse mesocolon of the adult is formed from 4 layers of peritoneum, i.e., the original transverse mesocolon (2 layers) plus the original dorsal mesogastrium to which it becomes fused (2 layers); and the transverse colon and its mesocolon automatically become parts of the floor of the omental bursa (see Fig. 120B).

Peritoneal Reflec-  
tions Adjacent to  
the Stomach

The reflections of the gastric and omental surfaces of the peritoneum as encountered by the surgeon may now be traced, both with regard to the greater peritoneal cavity and the omental bursa, furnishing a review of all the changes, rotations and fusions in the upper abdomen which lead up to final conditions in this region. Beginning at the porta hepatis (see Figs. 120 or 124) a peritoneal surface extends downward as the anterior leaf of the gastrohepatic or lesser omentum passing over the ventral wall of the stomach, then downward as the anterior leaf of the great omentum; thence back upward as the posterior (fourth) leaf of the great omentum until the transverse colon is reached; the peritoneal membrane, then, after passing over the inferior surface of the transverse colon is reflected to the posterior abdominal wall as the under surface of the transverse mesocolon. Beginning at the porta hepatis again another peritoneal surface passes downward forming the dorsal leaf of the lesser omentum, covers the dorsal gastric

wall, continues downward from the greater curvature of the stomach and back upward to the transverse colon as the innermost (second and third) leaves of the great omentum (i.e. inner lining of cavity of great omentum); thence over the anterior and upper walls of the transverse colon and backward to the posterior parietes as the uppermost layer of the transverse mesocolon; and from here upward and onward to the starting point at the porta hepatis, passing along posterior abdominal wall (parietal peritoneum), under surface of diaphragm and liver (posterior margin of coronary ligament of liver). The peritoneal reflections just described form the walls of the omental bursa which is bounded, then, as follows: the pouch extends behind and below the liver and stomach, above the transverse mesocolon, within the great omentum, and behind the small or gastrohepatic omentum.

The great omentum is familiarly known as the abdominal policeman on account of the frequency with which it is found at a site of peritoneal contamination. This great peritoneal fold seems literally to seek out sites of danger such as an infected appendix, an inflamed ovary, or a leaking gall bladder; it is often found efficiently walling off an infectious process from the general peritoneal cavity. Following this lead of nature the surgeon makes use of this protecting structure in many ways to cover areas which otherwise would be denuded of peritoneum, and by it to reinforce suture lines of doubtful strength. In some instances, for example peptic ulcers which have undergone acute perforations,<sup>159</sup> are closed with great difficulty due to the friability of the ulcer margins; while in others, closure by simple suture proves impossible. Each suture which the surgeon employs tears through the pathological tissue, creating an opening of larger and larger caliber. Here plugs or patches of adjacent omenta prove of life-saving value. Tabs from the gastrohepatic or gastrocolic omenta may be brought over the opening without undue tension, then sutured to healthy tissue beyond the circumference of the ulcer (Fig. 128). The omental transplants are sewed with great

Surgical Uses of  
the Omenta

care about the ulcer margins. The employment of one such graft from each of the adjacent omenta, forming two superimposed protecting layers, is particularly advantageous. Following

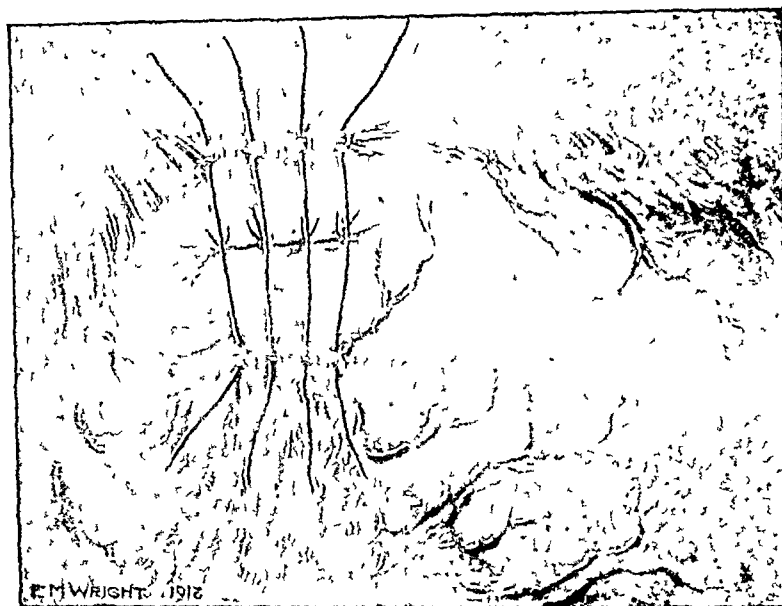


FIG. 128. Using omenta for reinforcement. Mode of closure of duodenal ulcer, whether perforating or not. The ulcer is enfolded and the gastrohepatic and gastrocolic omenta are sutured or ligatured together over the intestine. (From Moynihan's Abdominal Operations, Saunders)

closure of acute gastric perforations a gastroenterostomy may or may not be created, according to the indications as determined by the general condition of the patient and the amount of pyloric or duodenal obstruction at the site of repair.

The attachments of the stomach to the diaphragm and spleen are essentially simple; those to the pancreas are of such relative unimportance that they are as a rule omitted in any review of gastric connections, to be dealt with only under the heading of peritoneal relations of the pancreas.

The gastrophrenic ligament is a dignifying name given to a small fold of peritoneum which passes between the stomach and the diaphragm just to the left of the esophagus (see Fig. 3). It represents the slight traction on the under surface of the

Gastric Connections to the Diaphragm

diaphragm (peritoneum) caused by the rotation of the stomach to the right. The fold is avascular and has no surgical importance. Its chief anatomical interest is the fact that it forms one of the boundaries of the so-called raw, uncovered or triangular area of the stomach in which this organ is in direct contact with the diaphragm, this being the only part of the gastric walls devoid of peritoneum with the exception of the narrow lines along the curvatures between the attachments of the omenta.

The union between stomach and spleen is developed in a manner analagous to that by which the stomach becomes joined to the liver. That is, the spleen originates within the dorsal mesogastrium so that the stomach no longer is joined to the posterior abdominal wall by a mesentery but to the spleen by a ligament or omentum (gastrolenal or gastrosplenic ligament; old terminology, gastro-splenic omentum). (See Fig. 95.) This peritoneal fold is continuous with the gastrocolic or great omentum. The peritoneal covering of the anterior gastric wall is continuous with that forming the anterior leaf of the gastrosplenic ligament and the peritoneum covering the posterior gastric wall is continuous with the posterior leaf of the ligament; thus one ligamentous surface is related to the general peritoneal cavity while the other forms part of the lining of the omental bursa. Within this gastrosplenic ligament run the vasa breviae or the short vessels distributed to the fundus of the stomach and derived from the splenic artery. (See Sect. III—Spleen.)

Gastric Connections to the Spleen

The two small peritoneal duplications known as the gastropancreatic folds will be fully reviewed in dealing with the pancreas. The left gastropancreatic fold contains the gastric artery (coronary artery) and during subtotal gastrectomies the vessel is sometimes ligated within the fold as it approaches the lesser curvature (Fig. 129). This peritoneal fold forms the left limb of the uncovered or triangular area of the stomach. The band known as the right gastropancreatic fold does not reach the stomach at all but passes between the head of the

Gastric Connections to Pancreas

pancreas and the proximal duodenum; within it is found the proximal portion of the hepatic artery. (See vessels of enteric canal.)

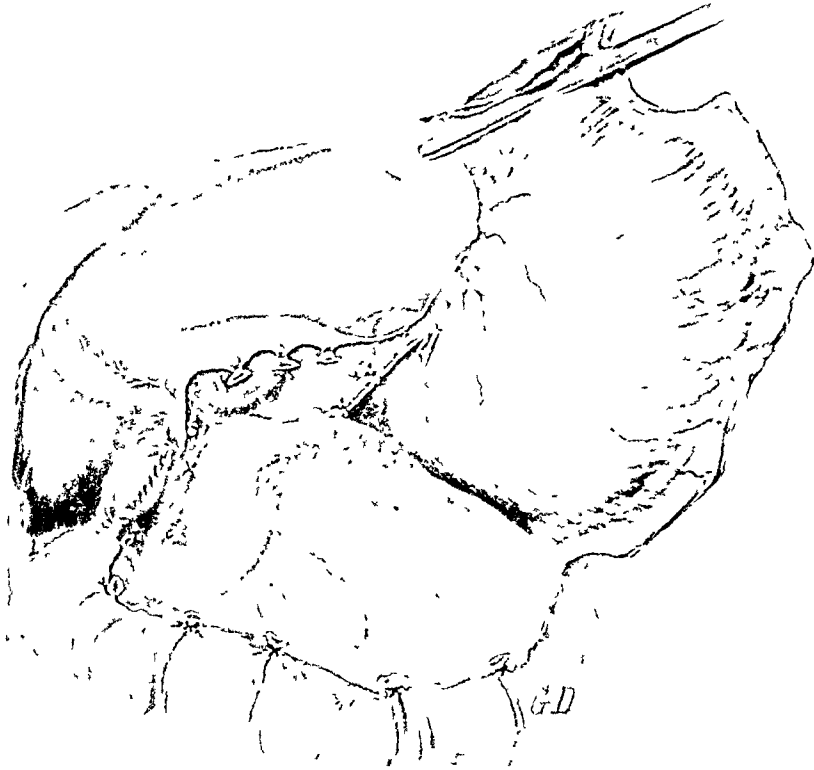


FIG. 129. Ligating left gastric (coronary) artery during partial gastrectomy. The duodenum has been divided and its distal extremity securely closed. The stomach has been raised and drawn over to the left side. Note the peritoneal fold (left gastropancreatic fold) formed by the peritoneum which surrounds the coronary artery. This fold, including the contained artery, has been doubly ligatured preliminary to its division. The gastroduodenal artery is indicated in the vicinity of the closed duodenum at the right side as it descends from its source of origin, i.e., the hepatic artery, in the pancreatico-duodenal sulcus. The transverse colon and its mesentery overlie the general mass of the small intestine (jejunum and ileum). (From Taylor's Operative Surgery, Wood.)

#### Summary

Briefly to recapitulate: The attachments or connections of the stomach are complex. All, however, are derived from the simple midline gastric mesenteries (ventral and dorsal) of early embryonic life. These peritoneal bands are termed gastric ligaments, omenta or epipla. They are double or compound

folds of serous membrane containing between their surfaces a thin sheet of extraperitoneal tissue. Omenta or gastric ligaments do not pass to the abdominal parietes but to other intra-abdominal viscera. The stomach is connected to the liver, transverse colon, biliary ducts, diaphragm, spleen and pancreas. Gastric connections are found at the curvatures only, leaving the broad surfaces of the stomach free. Of these one is related to the general peritoneal cavity and the other to the omental bursa.

Many additional practical points regarding these gastric connections suggest themselves for review. There might be studied, for example, means for gaining access to the posterior wall of the stomach, as for the performance of gastrojejunostomies; and methods for dealing with perforations, both of the pathological type, as represented by perforated and perforating ulcers, malignant and benign, and of the traumatic variety, caused by bullets and other penetrating foreign bodies or by rupture of the stomach without accompanying penetration of the abdominal walls. Again, changes in the position of the stomach with various periods of its physiological activity as the peritoneal reflections and bands allow these movements, invite attention in order that roentgenograms may be correctly interpreted, that the clinician may know at what sites gastric tumors may be palpated, and that a criterion may be gained upon which to estimate the presence or absence of gastropnoia and the relation of this condition to general visceropnoia. To deal with such topics at the termination of this postgraduate review of upper abdominal inter-relationships serves both as a means of making still more clear foregoing anatomical details and of enhancing the completeness of their practical application. This particular portion of the study of the abdomen and its contents holds more interest, perhaps, for the abdominal surgeon as an operator than as a diagnostician.

When an ulcer exists upon the posterior gastric wall the operator has a choice of 4 routes by which to approach the lesion. These are, the supragastric route, the infragastric

Practical Topics

Reaching the  
Posterior Gastric  
Wall

route, the transgastric route, and the infracolic route.<sup>160</sup> To gain access to the posterior wall of the stomach by way of the gastrohepatic or lesser omentum (supragastric approach) the

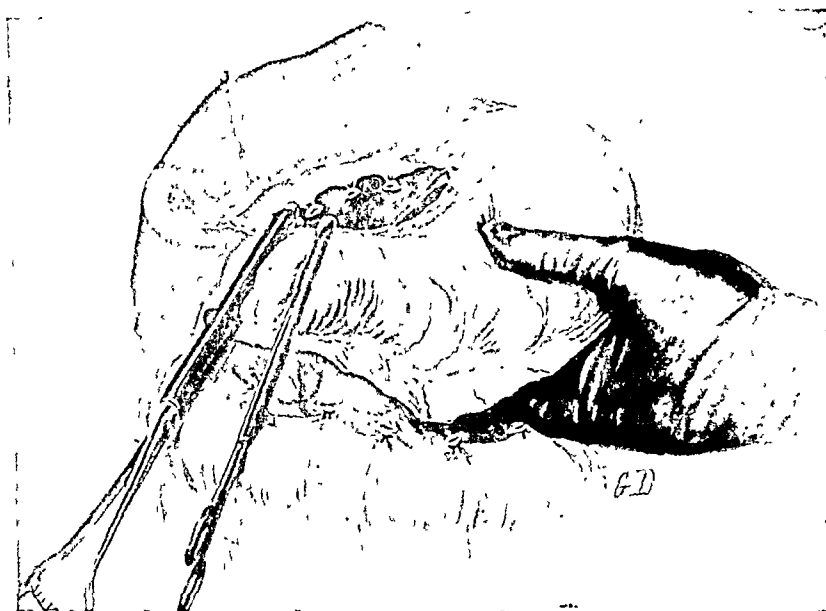


FIG. 130. Approaching posterior stomach wall and omental bursa by way of both the lesser omentum (hepatogastric ligament) and the gastrocolic ligament. (Subtotal gastrectomy). Smaller incisions through the ligaments may be used to examine the posterior gastric wall. (From Taylor's Operative Surgery, Wood.)

operator creates an opening of sufficient size to gain free entrance for the examining hand into the retrogastric space (omental bursa), doubly ligating and severing omental vessels if necessary; the ulcer is then freed by blunt dissection and the posterior wall with its contained lesion rotated forward and kept in view by means of a few stay sutures appropriately placed at or below the level of the ulceration. A similar procedure is employed when entering the omental bursa from below the greater curvature (infragastric approach); vessels within the gastrocolic ligament are ligated and divided, an opening is made through the ligament and the examining hand is inserted into the retrogastric space (Fig. 130). In dealing with ulcers of the posterior gastric wall by either of

these methods pads or sponges may be so introduced through omental openings to prevent general contamination of the lesser peritoneal sac.

The transgastric approach has the advantage of allowing a thorough inspection of the interior of the stomach. And this route may still be employed in cases in which ulcers are too adherent to the pancreas to be successfully rotated enough for adequate exposure from above or below. The method, however, presents the problems of how to control hemorrhage, how to prevent contamination of the omental bursa and of how to repair the posterior wall with the conventional double row of sutures. The best way in which to meet these problems seems to be the use, in addition to the incision into the anterior gastric wall, of incisions into the hepatogastric or gastrocolic ligaments, or both. Through these associated incisions gauze tampons may be packed into the bursa, as suggested, thus preventing widespread contamination; and hemorrhage from the posterior gastric wall, after the ulcer has been excised, is temporarily preventable by pressure against this tamponade, after which individual bleeding points may be caught and ligated. The technic for the transgastric approach may be summarized as follows; make an incision of convenient length (3 to 5 in.) in the anterior wall of the stomach parallel to the long axis of the organ and midway between the greater and lesser curvatures or opposite the site of the ulcer as palpated upon the posterior wall; ligate bleeding points; thoroughly inspect the interior of the stomach noting the size of the ulcer crater, the presence or absence of multiple points of ulceration, and making a gross differentiation between the malignancy or benignancy of the lesion; excise the lesion from the interior of the organ, using the aid of a hand of the operator or an assistant from within the omental bursa (accessory incisions as described previously); control bleeding points in the posterior stomach wall; retract the margins of the excision site on the posterior wall into the interior of the stomach, thus exposing the posterior peritoneal surface; take the desired seroserous sutures

Transgastric  
Approach to the  
Posterior Stomach  
Wall



(interrupted or continuous); now place the second row of sutures (through-and-through) in the posterior wall; close the anterior gastric wall in the usual manner, through-and-through



FIG. 131. Repair of posterior gastric wall by transgastric route.

- A. Sero-serous sutures in posterior wall.
  - B. Through-and-through sutures in posterior wall.
- Anterior wall sutured in usual manner.

row of sutures followed by a sero-serous row (Fig. 131). Gastric content, if present and troublesome, is dealt with by use of a suction tube. If the ulcer is found to be too adherent to the pancreas to be successfully freed (this is rarely the case), it may be excised and left attached to the pancreas while the gastric wound in the posterior wall is sutured exactly as though the lesion had been removed.

When the approach to the posterior gastric wall is desired for the purpose of making a posterior gastrojejunostomy this is accomplished by way of the transverse mesocolon (infracolic route): Withdraw the great omentum and transverse colon from the abdomen, turning them upward; render the transverse mesocolon taut, exposing the origin of the jejunum (for methods of locating proximal jejunum and positively identifying this loop see p. 292); apply a clamp to a bloodless point below the arch of the middle colic artery; make traction away from the omental bursa, and by a cut with scalpel or scissors, incise the transverse mesocolon near the clamp opening the retrogastric space (lesser sac); by blunt dissection carefully

Posterior Gastro-  
Jejunostomy

enlarge the hole in the transverse mesocolon to the size of about 3 in.; push the posterior wall of the stomach through this opening by means of a hand upon the anterior gastric

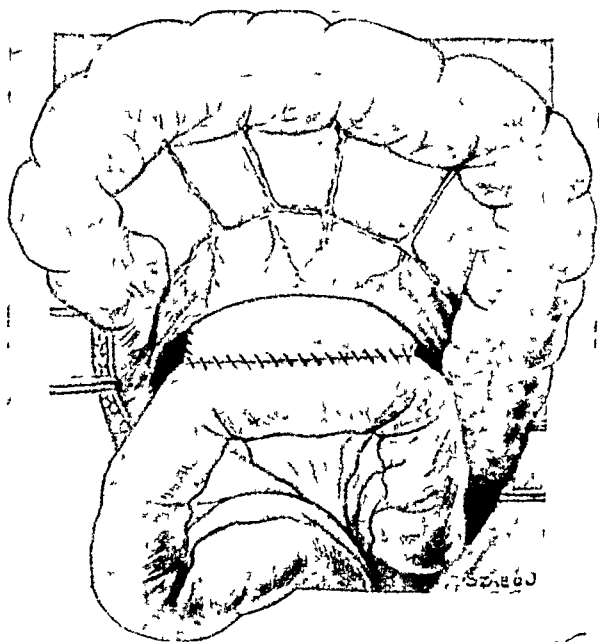


FIG. 132. Closing excess opening in transverse mesocolon after posterior gastrojejunostomy. Completed anastomosis showing opening in the transverse mesocolon to be attached to stomach or jejunum near suture line. (From Neuber )

wall. Discussions as to the exact methods for making the actual anastomosis (Caliber of stoma; length of jejunal loop; jejunal and gastric sites) will be found in textbooks on operative surgery. After stomach and jejunum have been united any excess opening in the transverse mesocolon is closed by sutures (Fig. 132). These may include the walls of the jejunum, those of the stomach, or both directly along the line of anastomosis. This closure of the transverse mesocolon is essential if hernial protrusion of the small intestine into the omental bursa is to be avoided.

It has been stated that since the surgeon has the choice of so many approaches to gastric ulcers and may employ so many combinations of these methods, there remains, as a rule, little

reason why he should not attempt by some method (cautery, knife, exclusion, inversion) to remove the pathological process<sup>161</sup> with its tendencies when not removed to persistent symptoms, to acute or chronic perforation, hemorrhage, and malignant degeneration.

Bullet wounds of the stomach almost invariably involve both gastric walls; hence a wound of exit is to be sought in the presence of a wound of entrance. Exceptionally the bullet remains within the lumen of the organ after passing through a single wall while less rarely one of the gastric curvatures is wounded, tearing away a single fragment and resulting in but one hole. But a very small area of the stomach surface can be injured by a penetrating foreign body without associated injury to other upper abdominal viscera. Figure 133 c shows the location of this surface zone; it represents the superimposition of two pictures, the one showing the relations of the anterior gastric wall, the other the relationships of the posterior gastric wall. Because of the almost certainty of injury to adjacent organs the opinion has been given that operations for gunshot wounds situated above the level of the umbilicus are inadvisable.<sup>162</sup> And it is known that operations have been undertaken which have proved useless because uncontrolled hemorrhage from the pancreas, liver, or some large intra-abdominal vessel has lead to a fatal outcome. Instances have been recorded, also, of spontaneous recovery after perforation of the stomach (Alexis St. Martin and others). Indeed, in the early years of the World War expectant treatment of upper abdominal penetrating wounds was the rule with all combatants.<sup>163</sup> According to Ochsner, however, "it was soon demonstrated that most penetrating wounds of the abdomen should be operated upon early," that the policy of "look and see" proved preferable to that of "wait and see," and that it became "mainly a question of excluding the few cases in which it was best *not* to operate" (those in extreme shock; those seen long after injury; those limited to

Bullet Wounds  
of Stomach

the liver area, etc.). Regarding bullet wounds acquired in civil life, there seems almost uniform agreement, that "accumulated experience shows the wisdom of operation"; that and in every

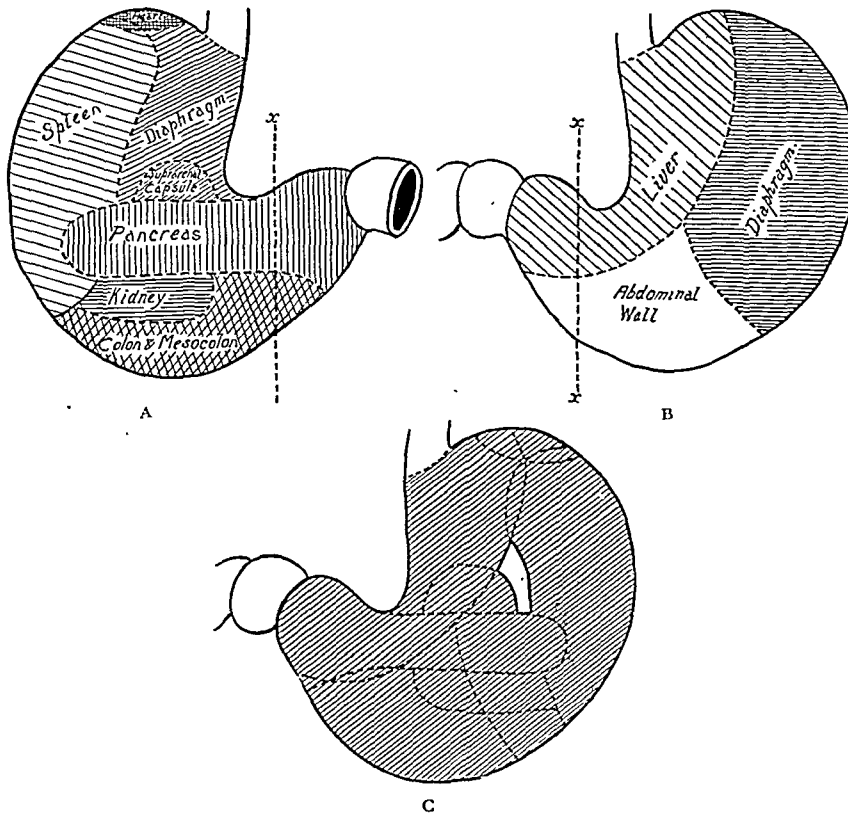


FIG. 133. Gunshot and stab wounds of stomach.

- A. Relations of posterior wall of stomach. (Testut.)
- B. Relations of anterior wall of stomach. (Testut.)
- C. A and B superimposed. The unshaded area shows only part of the stomach which can be wounded without injury being done to other organs. (Forgue and Jeanbrau.)

case of suspected penetrating wound of the abdomen operation "on principle" should be performed "with the utmost expedition." Strong evidence that this course is by great odds the safest procedure is summarized on p. 95; and end-results, it is known, are in direct proportion to the promptness of operative intervention. Exploration should be thorough, for with multiple injuries some sites of damage are easily over-

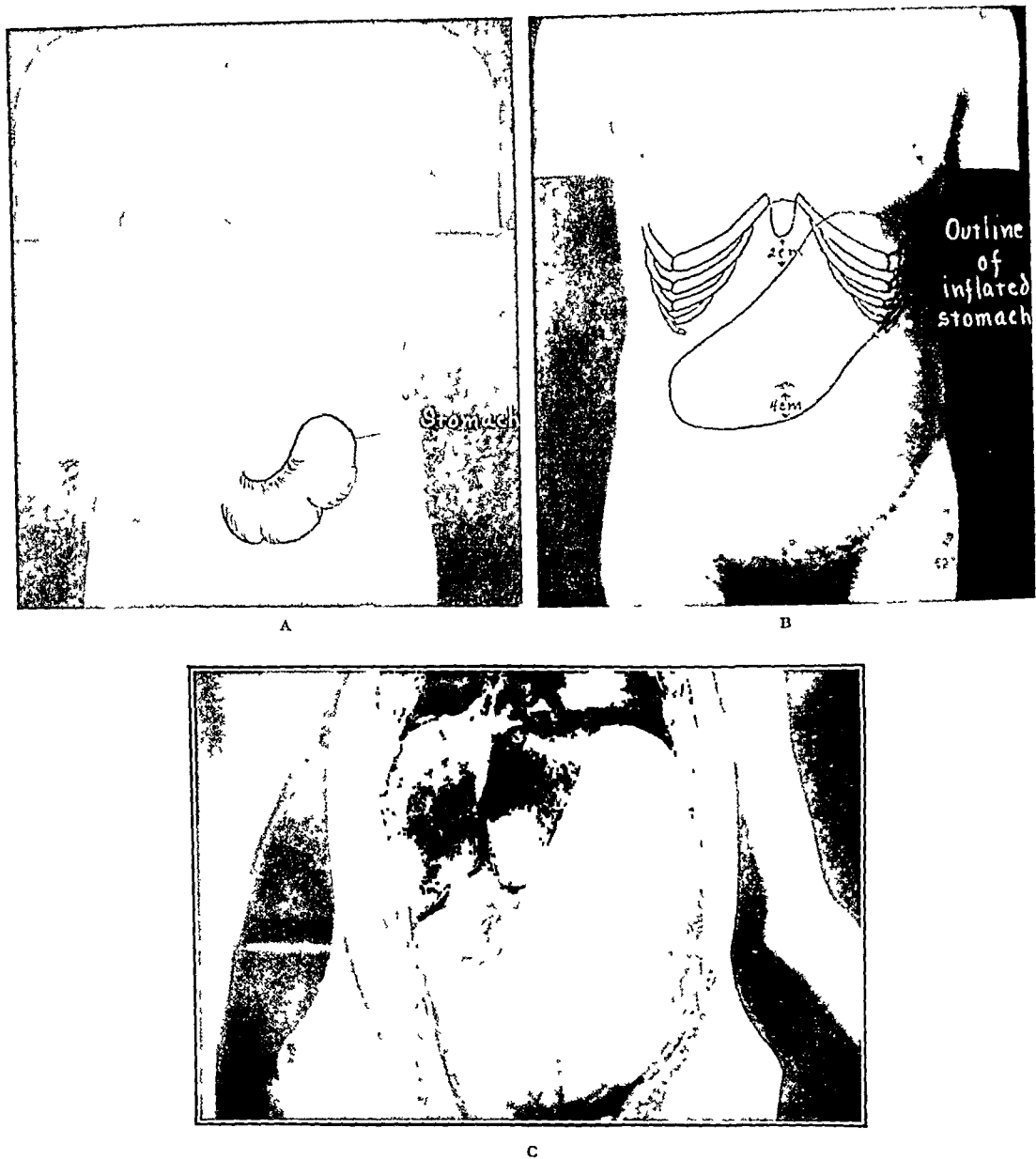


FIG. 134. Variations in position of stomach.

A. Gastropptosis. Note: this position of the stomach was associated with general splanchnoptosis but the model used for demonstration shows none of the thoracic or abdominal configuration actually observed with the patient.

B. Gastric dilatation associated with pyloric obstruction from chronic peptic ulcer. (A and B from Cabot.)

C. Extreme gastric dilatation due to duodenomesenteric ileus. (From Johnson's Surgical Diagnosis, Appleton.)

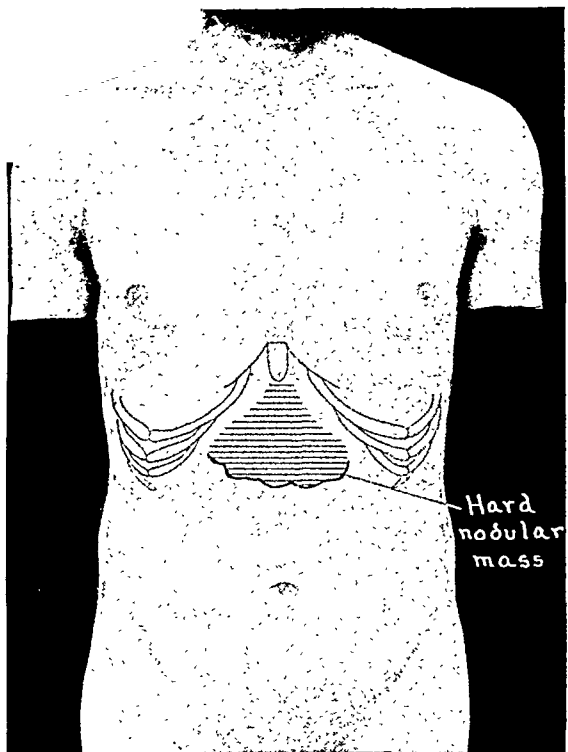
looked. With gastric perforations damage to the small intestine, colon, omenta, mesentery, liver, pancreas and kidneys are to be suspected, depending upon the track taken by the bullet; injury to the diaphragm is to be kept in mind with the possibility of diaphragmatic hernia formation. Even when the condition of the patient (shock, hemorrhage) seems poor the exploration should be systematic and complete; otherwise the operation for bullet wounds is but a sham. The posterior gastric wall may be approached by any of the methods described and gastric wounds of either or both surfaces are to be closed by a double layer of sutures (through-and-through layer covered by seroserosal layer) while omental patches or grafts may be used as reinforcement if desired.

From the foregoing study of gastric attachments it is evident that the only truly fixed portion of the stomach is at its esophageal extremity (cardia and raw or triangular area). The lesser curvature is relatively fixed by the suspending lesser omentum but by this arrangement the stomach naturally suffers displacements with displacements of the liver. The greater curvature is freely movable, the stomach sliding easily over surrounding peritoneal surfaces, movements being particularly facilitated by the presence behind, of the omental bursa (Fig. 134 A-C). The diagnosis of gastropptosis was formerly more often made than at present. And operations devised to correct this supposed defect have largely passed from favor. The greater curvature in over 80 per cent of healthy men and women extends, after a barium meal, well below the interiliac line and with great frequency into the pelvis. The tonicity of the gastric musculature and the weight of the gastric contents play important rôles in determining the level of the organ within the abdomen. Based upon roentgenographic evidence regarding the position of the stomach in healthy adults it has been concluded that "many patients and many physicians have in the past been unduly concerned about so-called low positions of the stomach."<sup>164</sup> Unless the patient is of the

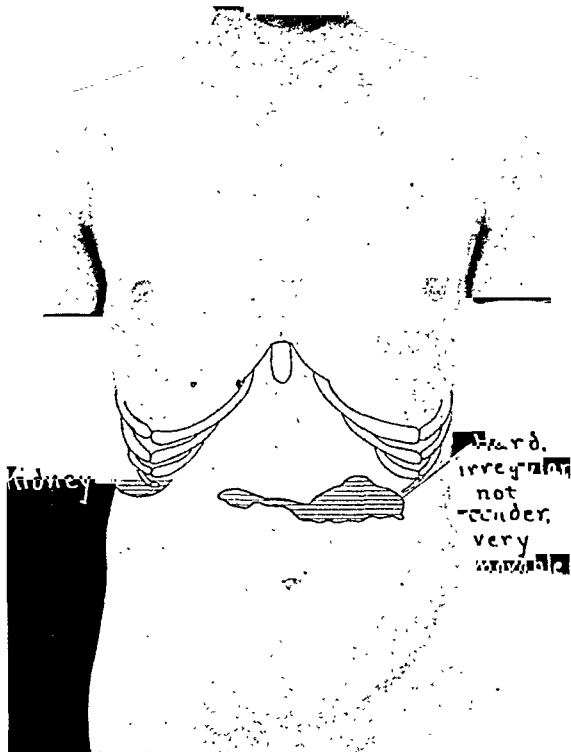
Gastropptosis

enteroptotic habitus or has definite evidence of ptosis of other viscera the diagnosis of gastropptosis as an isolated entity seems seldom to be warranted.

Because of the extreme variability as to the position of the normal stomach at various phases of its physiological activity gastric newgrowths may be palpated at widely different points. More than one-fourth of all carcinomata are situated in the stomach; and 80 per cent of patients with cancer of the stomach present at some time in the course of the disease a palpable gastric tumor. Notwithstanding these striking figures and the extreme frequency of such masses, palpable tumors do not play the important part in the diagnosis of cancer of the stomach which might be expected. Both a palpable mass and a visible gastric outline due to pyloric obstruction are relatively late signs (Fig. 135A-C). And for early diagnosis, the prime requisite to successful treatment, laboratory data (occult blood; positive roentgenogram) take decided preference over the findings upon physical examination. Not only are palpable masses relatively late in developing but the absence of such a mass is not an index of the absence of cancer. Every experienced clinician has met with cases in which the roentgen ray has demonstrated extensive malignant involvement of the stomach later confirmed by operation or autopsy, where repeated painstaking physical examinations have failed to give the slightest assurance that the lesion was present. Numerous factors contribute to the ease with which gastric growths may escape detection; the pyloric extremity of the organ is at times lodged below the margin of the liver and when the stomach is full the pylorus may be pushed 2 in. to the right of the midline; cancers of the cardia cannot be felt; and tumors on the lesser curvature, posterior wall and fundus often are difficult to map out since normally only the lower part of the greater curvature comes in contact with the anterior abdominal wall. In addition to being of rather late development and readily escaping detection masses, even when present, may



A



B



c

FIG. 135. Late physical signs with gastric carcinoma; palpable mass; visible gastric outline from obstruction.

A. Carcinoma of greater curvature. (From Cabot.)

B. Carcinoma of greater curvature and gastrocolic omentum. (Cabot.)

C. Carcinoma of pylorus with pyloric obstruction causing visible gastric distention.

(From Quervain.)



defy positive identification. It is not always easy and is at times impossible to state either that the mass is situated within the stomach or that it is malignant in character. So great is the range of gastric movements (epigastrium umbilical zone, hypogastrium, hypochondria) and so many are the other masses common within this wide range (tumors of gall bladder, liver, pancreas, mesentery, transverse colon, small bowel) that absolute identification of gastric growths proves most difficult.

To attempt the diagnosis of gastric cancer, then, by bedside methods alone is to give up hope of early diagnosis,<sup>165</sup> which is somewhat akin to giving up hope of obtaining favorable results from treatment; and to render a prognosis upon information obtained by physical examination alone, without aid of laboratory data or exploratory incision, implying as this does that the diagnostician is *positive* the mass in question is located within the stomach and is *certain* that it is malignant, is both unwise and inconsistent with the importance of the prognostic judgment to the patient and to relatives.

#### B. ANATOMICAL AND PHYSIOLOGICAL DIVISIONS OF THE GASTROINTESTINAL TRACT

I. ANATOMICAL DIVISIONS. The enteric canal has both anatomical and physiological divisions. These are quite distinct from each other as to location and limits and will be studied separately. Reference to the former has been freely made in foregoing pages and they will here be but briefly considered for with these divisions the practical surgeon is of necessity thoroughly familiar. Such knowledge is implied even by the names of the various operations and these could not be performed without comprehensive acquaintance with anatomical details. The procedure, for example, by which the gall bladder is united with the enteric canal is termed as cholecystogastrostomy, cholecystoduodenostomy, cholecystojejunostomy, or cholecysto-transversostomy, depending upon the exact point in the gastrointestinal tract utilized for the anastomosis.

The names applied to the several anatomical divisions of the alimentary canal are largely terms descriptive of certain gross

appearances. The first portion of small bowel, a loop approximately twelve fingerbreadths in length, is the duodenum (L. *duo*, two + *denum*, ten); the subjequent portion which is usually found to be empty when examined post mortem, is the jejunum (L. *jejunus*, empty); that especially tortuous distal third of small bowel is the ileum (Gr. *ileo*, 1 roll up; twist); the closed end of large bowel is the cecum (L. *caecus*, blind); the small worm-like unit attached to this pouch is the vermiform appendix (L. *vermis*, worm + *forma*, form) (L. *ad*, to + *pendere*, to hang). The terms *intestinum crassum* (L. *crassus*, coarse; thick, wide) and *intestinum tenue* (L. *tennis*, thin, fine) distinguish by calibre the two main intestinal divisions, large and small. The word *esophagus* comes from two root-words meaning to eat and to carry, hence the name fittingly describes this 9 in. musculomembranous tube extending from pharynx to stomach, as a passage way for food. The pylorus (Gr. a gate-keeper) guards and controls the lower orifice of the stomach. The word *bowel* (L. *botellus*; *botulus*, sausage) describes the shape of the tract but also signifies something deep in situation, while the term *intestine* (L. *interaneus*, interior) likewise indicates the position of the alimentary tract (L. *alimentum*, food), which together with its glandular outgrowths as already noted practically fills the belly (a muscular bag).

Terminology

The dividing lines separating anatomical units are easily recognized. The esophagus is separated from the stomach by the cardiac sphincter; the union of stomach with duodenum is marked internally by the pyloric ring and externally by the visible pyloric vein (Mayo's vein); the jejunum begins at the point where the small bowel pierces the transverse mesocolon; the ileum ends at its junction with cecum (ileocecal valve); which also marks the beginning of the ascending colon; the transverse colon terminates at its two extremities in colic flexures (right and left); the descending colon ends opposite the left iliac crest.

Anatomical  
Boundaries

The single divisional point which the operator cannot exactly locate is the junction of jejunum with ileum for this is an

Jejunioileal  
Junction

indefinite blend, the ileum being roughly the last 12 ft. of small bowel. Small bowel measurements are made either downward from the duodenojejunal junction or upward from the ileocecal

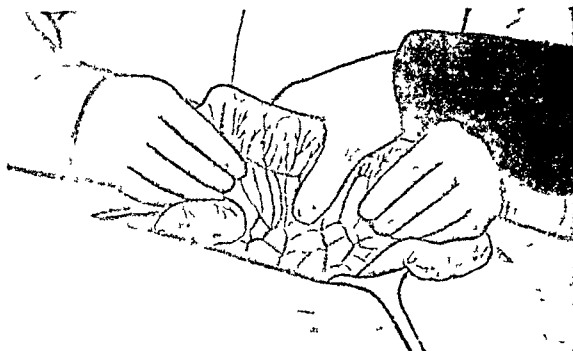


FIG. 136. Method for determining the real direction of an isolated loop of intestine by palpation of the mesenteric root. (From Monks, *Surg. Gynec. Obst.*)

valve but cannot be taken from the jejunioileal union since this is but an arbitrary point of blending of these divisions.

Intestinal Locali-  
zation

This lack of any fixed and readily located landmark within the jejunioileal portion of small bowel is a decided handicap for the operator since it leaves him without a simple means of orientation with regard to approximately 20 ft. of bowel. How is he to know in handling individual intestinal loops which extremity is cephalad and which caudad; how is he to estimate the distance of the various segments from duodenum or cecum unless he traumatizes all intervening bowel by taking actual measurements? In creating intestinal anastomoses or stomata, in seeking points of intestinal obstruction, and in numerous circumstances and for various reasons it is important that the surgeon be able to identify, at least roughly, the portions of bowel with which he deals.

Monks has shown that the determination of direction in any intestinal loop may be made by examining the relation of the loop to the root of its mesentery. The procedure is as follows:<sup>166</sup>

Draw the loop in question well upward in the abdominal wound; direct an assistant to hold the loop by its extremities within the plane of the mesenteric root (Fig. 136); now ascer-

tain by inspection or palpation whether there is or is not a twist within the mesentery supplying the loop; if no such twist exists it naturally follows that the upper extremity of the loop



FIG. 137. Various positions occupied by the appendix. (From Deaver.)

is its cephalic end while the lower extremity of the loop is its caudal end. If upon palpation it is determined that a twist exists in the mesentery of the bowel, the loop should be rotated and palpation repeated; when no twist remains, the upper extremity of the loop as it is then held, is nearest the duodenum and the lowest extremity is the one nearest the ileocecal junction. In determining whether or not a twist exists in the mesentery of the loop in question, the surgeon may grasp the intestine in such a manner that his thumb is on one side of the mesentery and his fingers upon the other and by pushing his hand toward the mesenteric root he may conduct his examination by gently sliding his hand upward or downward along the base of the mesentery. Or, the mesenteric root may be palpated by passing the open hand along one side only. Again, the surgeon may determine the condition of the mesentery by traction on the wound margins and by inspection.

Palpation of the  
Root of the  
Mesentery

The terminal ileum may be located by finding the ileocecal junction as the finger is passed from above downward along

Finding the Terminal Ileum and the Appendix

the medial border of the ascending colon. At times the ileocecal junction may lie within the pelvis minor. In such instances the examining finger must pass over the right psoas muscle and iliac vessels before encountering the terminal ileum. The base of the appendix is found springing from the medial and posterior part of the cecum about 1 to  $1\frac{1}{2}$  in. below the ileocecal orifice. The anterior tinea of the cecum forms the surest guide to the base of the appendix. The appendix (tip) has been found in every possible situation within the abdomen which the location of the cecum and length of the appendix and meso-appendix allow.<sup>167</sup> The appendix usually courses over the pelvic brim, upward behind the cecum, or upward and medially toward the spleen (Fig. 137).

The differentiation between loops of ileum and those of jejunum is frequently of great importance. As pointed out there is no sharp demarcation between these portions of the small bowel and variations in structure and appearance between them take place gradually. Differences are, naturally, most marked near the extremities of the respective anatomical divisions and by being acquainted with these variations the surgeon may estimate with fair accuracy the identity of the particular loop of bowel which he may chance to encounter and desire to localize. Credit for emphasis upon these details for localization belongs chiefly to Treves and to Monks. It is largely from the writings of the latter that points which follow are derived.

The essential differences between the upper and the lower limits of the small intestine supplied by the mesentery proper (mesenterium) may be summarized thus:<sup>166</sup> In the proximal jejunum the loops are, as a rule, larger; have thicker walls; are more vascular; have more marked plicae circulares (valvulae conniventes); and are supplied with fewer and smaller lymphatic patches; their mesenteric attachments have larger, straighter vessels and are more translucent and free from fat tabs (Figs. 138 A and 139 A). Upon the other hand in the terminal ileum the loops are smaller; have thinner walls; are less vascular;

have few or no plicae circulares; and are plentifully supplied with large lymphoid patches (Peyer's patches) (see absorptive functions); their mesenteric attachments have smaller, arched

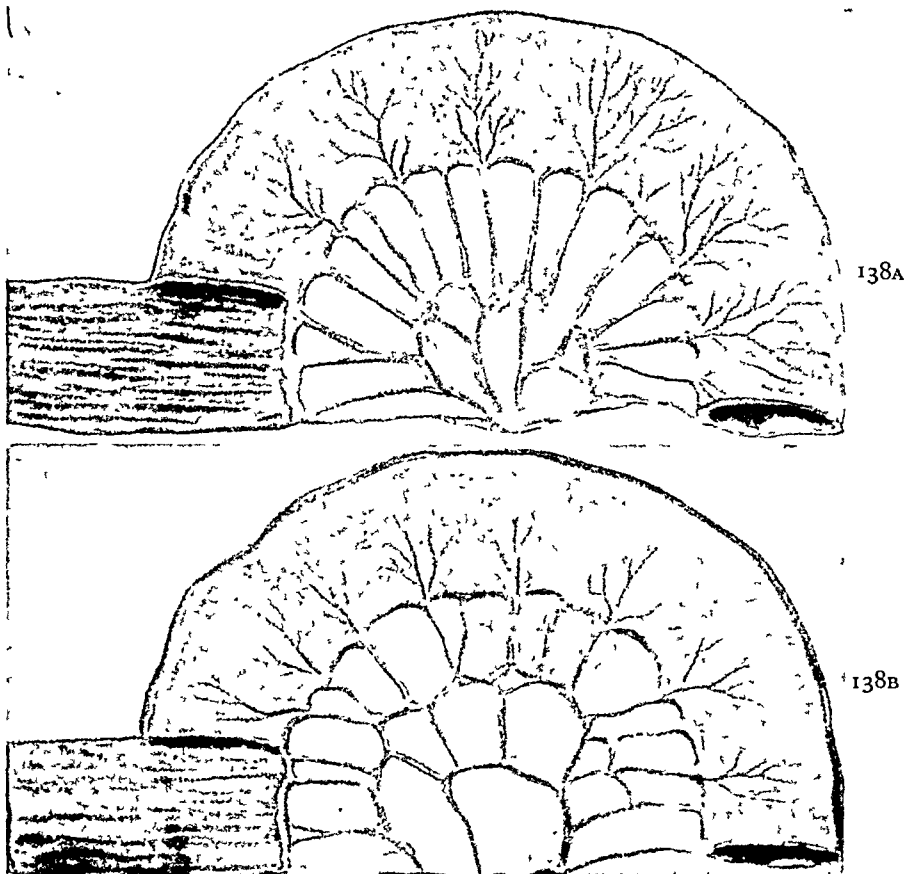


FIG. 138. Localization of jejunoileal loops. (From Monks, *Surg., Gynec. Obst.*)

A. Upper jejunum. Note, size, thickness and vascularity of bowel; also the abundant coarse valvulae conniventes. Observe that vascular arches in omentum are largely primary and that bowel wall is reached by vessels which are large, long, and straight. (Obviously a segment of high digestive or functional activity.)

B. Lower ileum. Note bowel is smaller caliber, thinner texture, and less vascular (i.e., vessels pass but short distance to bowel wall and arborize but little); valvulae conniventes are fewer and smaller (obviously a loop of less functional importance). Observe that the vascular arches in the omentum have secondary and tertiary loops while the bowel is reached by vessels which are shorter, and somewhat tortuous.

vessels, and are more opaque and laden with fat (Figs. 138 B and 139 B). These differentiating characteristics will be individually emphasized.

Size: The normal size of the jejunal (upper) loops is from  $1\frac{1}{4}$  to  $1\frac{1}{2}$  in.; that of the ileum is about 1 in. in diameter. In pathological states these normal measurements may be lack-

Jejunum vs. Ileum

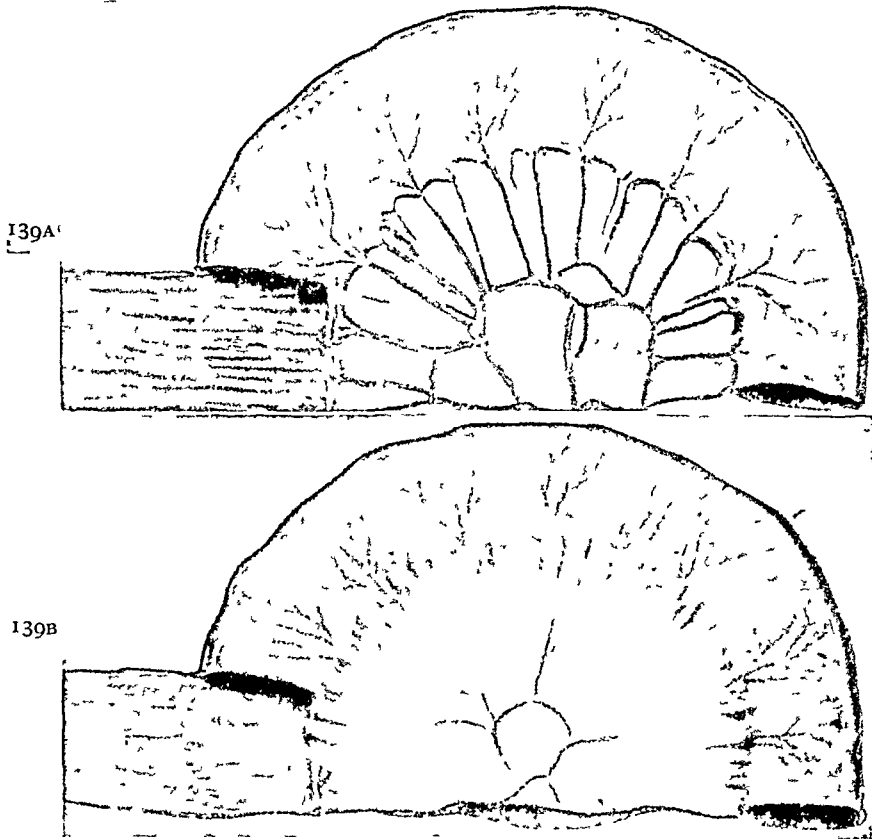


FIG. 139. Showing same differences between upper and lower loops of small intestine (jejunum and ileum) as illustrated in Figure 138 but in a fatter individual. (From Monks, *Surg., Gynec., Obst.*)

A. Upper loop.

B. Lower loop.

Observe differences of fat distribution in upper and lower loops and in B (lower loop) the little tabs of fat encroaching upon the wall of the intestine itself, a condition typical in lower ileum.

ing, the caliber of the bowel depending largely upon the tonicity of the musculature, being small with spasticity and large or dilated in relaxed states. Thus, while, one might carelessly assume that the small intestine would grow larger and larger as the large intestine was approached, the reverse proves

true. Indeed, this is analagous to the condition in the large bowel where the proximal portion (cecum and ascending colon) is of much larger caliber than the distal portion (descending and iliac colon).

**Thickness:** The jejunal walls are heavy and thick suggesting an ample musculature and a high degree of physiological activity. The ileal walls are light and thin in comparison and lack the fleshy feeling noted in the upper jejunum.

**Valvulae conniventes:** As the intestinal loop is gently stroked between the thumb and forefinger the plicae or transverse folds may be felt as the fingers roll over them. These are abundant high in the small bowel and scanty or wanting in the terminal ileum.

**Lymphatic patches:** Upon the other hand the localized accumulations of lymphoid tissue (Peyer's patches) are more abundant from above downward, being numerous in the terminal ileum. It is not always easy to make out these patches by palpation.

**Vascularity:** Little vessels, the vasa recta, pass onto the intestinal walls, coming from the mesenteric arches and ramifying or arborizing upon the bowel wall transverse to its long axis. These alternate, as a rule, from one side to another (see Fig. 138 A). Upon the jejunum this supply to bowel wall is rich, the vessels being longer, more branched and more numerous than in the ileum where they are short, scanty, and largely devoid of arborization.

The main vessels of the superior mesenteric artery unite to form a series of arches with their convexities directed toward the intestine. In the upper jejunum these arches tend to be placed at a distance from the intestinal wall, and are usually single or primary and from these primary arches, long vessels of large caliber, pass in a straight course from the depths of the mesentery to the bowel. In the ileum the arches in the mesentery are more numerous forming secondary and tertiary arcades; while the vessels passing to the bowel are shorter, more tortuous and of smaller caliber.



Mesenteric fat: In the terminal ileum the fat present may obscure the vessels and the mesentery appears very thick and opaque while characteristic little tabs of fat pass from the mesentery onto the wall of the intestine. In the jejunum the vessels are more readily visible and the mesentery thinner and more translucent while fat tabs do not tend to pass to the bowel wall.

As would be expected there is much variation in different individuals as to the total amount of fat present, but in general the difference in distribution between the upper and the lower portion of the mesentery is quite obvious.

In summarizing his work Monks wrote: "It is not by any one of these signs, but by a combination of them, that the surgeon makes his estimate as to the level of bowel to which the isolated loop belongs; while his localization may not be very exact, when he needs the information the localization, as he has made it, is probably better for his purpose than no localization at all."

Cystic masses occur within the mesentery but the diagnosis of mesenteric cyst is solely one of position since these tumors vary considerably as to pathological character. Mesenteric cysts may be lined by mucous membrane (misplaced or embryonic intestinal tissue) endothelial cells (distention of closed peritoneal pouches) or other tissues (dermoid cysts, lymphatic cysts, single or chylous, remnants of Wolffian body).<sup>168</sup> These cysts are rounded, well defined, tense, elastic and movable; they are usually located upon the right side of the abdomen below the umbilicus. Since their only connection is with the mesentery or intestine a physical sign of some value is the ability to move the mass freely from side to side (upon the mesenteric hinge) but little or not at all at right angles to this direction (i.e. up and down). These rare tumors may cause symptoms ranging from slight abdominal fulness or a vague sensation of discomfort to recurrent attacks of colic and vomiting or acute symptoms of intestinal obstruction due to kinking of the bowel; at times the interference, the functional

#### Mesenteric Cysts

integrity of intestinal vessels and nerves produce symptoms of spastic constipation or the opposite, those of gastroenteritis.

Aside from difficulties relative to intestinal localization and in differentiating loops of ileum from those of jejunum, the only other common point of confusion, regarding the anatomical divisions of the gastrointestinal tract concerns that portion of large bowel known as the sigmoid colon. This term does not appear in the Basle International Anatomical Nomenclature (B. N. A.) but is frequently encountered in clinical texts; and the "sigmoidoscope" is a well known part of the surgeons' diagnostic armamentarium. Correctly speaking the portion of bowel between the end of the descending colon (at the level of the left iliac crest) and the beginning of the pelvic colon (medial border of left psoas major muscle) is termed the iliac division, while the bowel which extends from this last named boundary to the junction with the rectum (at about the level of the third sacral vertebra) is known as the pelvic colon. The iliac colon is from 5 to 6 in. in length and has no mesentery; the pelvic colon is from 16 to 17 in. in length and is supplied by a mesentery of considerable width. The term sigmoid colon, or omega loop, by some authorities is applied to all of the bowel from the iliac crest to the level of the third sacral vertebra (i.e. to both iliac and pelvic divisions) making a segment partly with and partly without a meson. Other authorities use the terms sigmoid colon and pelvic colon synonymously, as referring exclusively to that portion which has a mesentery. The practical point to be noted is this: an instrument passed through the rectum must be about 30 in. long to reach the end of the descending colon (if indeed this be the upper limit of the sigmoid) or 23 in. to reach the upper limit of the pelvic colon (if this be considered the upper end of the sigmoid). But the instrument commonly termed a sigmoidoscope is only from 10 to 12 in. in length. It is clear, then, that in passing a 12 in. instrument into a 20 to 30 in. canal, the end of the segment cannot be examined; and it cannot be said after a sigmoidoscopic examination that "there is no

The Sigmoid  
Colon

Level of the Sig-  
moidoscopic Ex-  
amination

newgrowth or abnormality within the sigmoid colon." Cases will be noted in which a roentgenogram will reveal a sigmoid mass while in the same case a rectal consultant will state that the sigmoidoscopic examination is negative; the explanation of the apparent discrepancy being that the mass is located within either iliac or pelvic colon but at a distance of more than 15 in. from the anus (beyond sigmoidoscopic vision). It seems advisable to refer to a sigmoidoscopic examination in terms of the specific number of inches or centimeters from the anus traversed by the instrument and to drop the use of the term sigmoid colon in favor of the more exact terms, iliac colon and pelvic colon.

## EPONYM

HENRY HEAD\* (English physician. Contemporary)

"Areas of cutaneous hyperalgesia occurring in cases of acute or subacute visceral disorders."

Head's Areas  
Head's Zones

The accompanying photostatic copy of excerpts from Head's original article shows that he had a dual object in mind in writing his paper, first of investigating the pain and accompanying tenderness consequent on visceral disorders and second of mapping out on the surface of the body the skin areas supplied by the various segments of the spinal cord. That is, he studied in part viscerocutaneous relationships and in part spinal segmentation without reference to visceral diseases.

Discussion of  
Eponym

This dual nature of the paper and the completeness of the theoretical charts and cuts appended, caused some confusion and misinterpretation. Head himself carefully pointed out that certain of the skin zones which he delimited by his investigation were never involved as a result of visceral disorders. These zones represented silent areas and he referred to them as "gaps." He also observed that skin tenderness seldom completely filled cutaneous cord zones but was rather to be found at fixed points known as "maxima," situated somewhere within the zonal boundaries. Notwithstanding his emphasis upon such matters textbooks appeared shortly after publication of his paper which reprinted the surface maps or "Head zones" with notations to indicate that every surface zone in the body was related to some internal organ and that when any organ was diseased skin tenderness would be found neatly distributed over some surface segment which was diagnostic of involvement of that particular organ. Such ideal pictures naturally were not found upon physical examination. And early attempts to over-apply Head's observations without regard to many details which he insisted were important, and made in advance of more laborious and complete clinical investigations of individual viscera to determine the relative frequency with which each caused surface changes and of the type of disease or stimulus which set up such changes, brought suspicion and some discredit upon the whole theory of viscerocutaneous phenomena. Among requirements pointed out by Head as important in intelligent use for diagnosis of surface sensory changes caused by visceral disorders are a careful, deliberate, and systematic sensory examination; separate study of the various forms of skin sensitivity; an understanding of differences between peripheral nerve distribution and spinal segmentation; knowledge concerning the sympathetic nervous system and of why certain surface zones are clinically silent or represent gaps with regard to visceral diseases. Head also emphasized the importance of properly interpreting the relation between maximal points of tenderness (maxima) and segmental areas in their entirety; also of being conversant with the "laws of spread" of cutaneous disturbances originating at fixed points, to other regions or more remote segments (sensory "generalization"). Some understanding of such matters is a prerequisite to an evaluation both of viscerosensory phenomena in general and to Head's contribution to this phase of clinical diagnosis.

In his pioneer work Head acknowledged the antecedent studies of Ross and others regarding the reference of pain caused by visceral diseases to definite areas of the body wall. He highly evaluated the contemporary investigations of Mackenzie who was the first to point out the presence of tenderness within areas to which pain was referred and to suggest the use of such tenderness as an objective sign in testing for body wall changes

\*A sketch of the life of Head will appear when this material is published in book form.

# BRAIN:

## A JOURNAL OF NEUROLOGY

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FOR THE NEUROLOGICAL SOCIETY OF LONDON

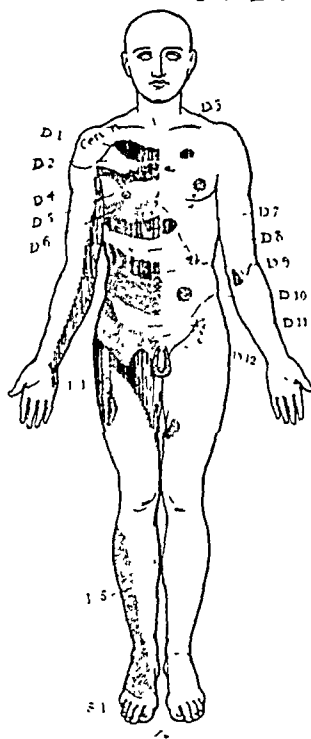
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VOL XVI



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AND NEW YORK  
1893

PLATE I



# BRAIN.

PARTS I & II, 1893

Original Articles

ON DISTURBANCES OF SENSATION WITH  
ESPECIAL REFERENCE TO THE PAIN OF  
VISCERAL DISEASE.

BY HENRY HEAD M.A., M.D.  
*Lecturer in College Hospital*

INTRODUCTORY

SEVERAL years ago I was led to examine the positions occupied by pain in disorders of the stomach and I soon came to the conclusion that the usual description was incomplete in several respects. For firstly the positions over which the patient experienced pain in gastric disturbances were more numerous than was usually supposed, and secondly the pain was in many cases associated with definite cutaneous tenderness. Moreover the cutaneous tenderness was in many cases not confined to small spots or areas but occupied whole tracts of skin with definite borders. I was thus led to investigate the pain and accompanying tenderness consequent on disturbances of other organs, and I found that these sensory disturbances also followed definite lines.

After Ross's most suggestive papers it seemed exceedingly probable that these areas bore some definite relation to nerve distribution, and I then began to investigate the distribution of herpes zoster in the hope that a skin lesion which was notoriously of nervous origin might throw some light on the meaning and significance of the tender areas in visceral

<sup>1</sup>Read as a Thesis before the University of Cambridge June, 1892, and before the Neurological Society of London, November 10th, 1892.

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## 2 ON DISTURBANCES OF SENSATION WITH ESPECIAL

disease. To my surprise I found that the areas occupied by herpes zoster exactly corresponded to those with which I was familiar in visceral disease.

I next attempted to determine to what level of the nervous system these areas belonged, with the help of cases in which gross organic lesions were present. By this means it became apparent that each of these areas represented the distribution of either a single nerve root or of a single segment in the spinal cord.

Thus I was enabled to map out the areas supplied by the various segments of the cord on the surface of the body. It then became apparent that certain of these areas were never affected in visceral disease, and this led me to examine the sensory supply of the viscera from the sympathetic system. Now Ross had already suggested that in visceral disturbances pain (and therefore in my cases tenderness) was referred along the distribution of the somatic nerves which came off from the same part of the cord as the sensory sympathetic fibres to the organ affected. Thus if I could map out the somatic areas along which pain was referred in visceral disease I could say, on Ross's hypothesis, what was the sensory supply from the sympathetic of the particular organ affected. By this means I obtained another scheme showing the distribution of the sensory sympathetic fibres analogous to that which Gaskell constructed for the motor and inhibitory fibres of the same system.

The next question that arose was whether these tender areas appeared only in visceral disease, and I soon found that they appeared to a greater or less extent in many general diseases, such as anæmia, ague and fever of all kinds.

In the present paper I shall confine myself to the discussion of the disturbances of sensation, &c., below the level of the clavicles, for although every general statement applies equally to the head and neck and the body below the clavicles the problems opened up by a consideration of the areas of tenderness occurring in the head and neck are so wide reaching that I must reserve them for a subsequent paper in the near future.

FIG. 140A. Facsimile of introduction and plate from Head's original article.

[360]

If impulses pass up the sensory nerves from an organ which is diseased, to the cord they will set up a disturbance in the segment of the cord to which they are conducted. Now any second sensory impulse from another part conducted to the same segment of the cord will be profoundly altered. Under normal circumstances it would have set up its own proper disturbance in the grey matter and this disturbance would have been conducted to the brain. But now it no longer falls into a normal and quiescent cord but into one whose activity is already disturbed. The resultant stimulus conducted upwards is therefore a very different one from that which would have passed on under normal circumstances. In many cases the second stimulus will be exaggerated like rays passing to the eye through a convex glass. Thus if any segment of the cord is disturbed by painful stimuli from an internal organ a stimulus applied to the skin over the areas supplied by the nerve roots belonging to this segment will be exaggerated and a stimulus which normally was perhaps only uncomfortable would now appear to be very painful.

Thus, as our viscera are so notoriously insensitive, and as we have never had the opportunity of developing the sense of localisation in them, owing to their inaccessibility to touch, it is not to be wondered at that the maximum pain is not felt in the organ affected. They are thus as regards the localisation of sensation in exactly the position of the area on the skin whose sensation of pain was diminished in comparison with that of its neighbour. A painful stimulus to an internal organ is conducted to that segment of the cord from which its sensory nerves are given off. There it comes into close connection with the fibres for painful sensation from the surface of the body which also arose from the same segment. But the sensory and localising power of the surface of the body is enormously in excess of that of the viscera, and thus by what might be called a psychical error of judgment the diffusion area is accepted by consciousness, and the pain is referred on to the surface of the body instead of on to the organ actually affected. I do not mean to state that pain is never referred to the organ affected. Far from it. The pain is frequently felt in the organ itself but it is "dull," "heavy," "weaving," and not "sharp," "aching," "stabbing," like the referred pain.

Thus I believe that the phenomena of allochæmia and of referred pain in visceral disease are in nature and explanation essentially the same. Both depend for their appearance on the law that where a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied.

## §2 The relation between the tender areas in visceral disease and the areas affected in herpes zoster

Before I proceed to describe the limits of the tender areas in visceral disease I must digress for a moment to point out how I have been helped in this investigation by certain trophic skin lesions, especially herpes zoster.

Now these points correspond to the positions of pain and maximum tenderness in visceral disease. Thus the areas occupied by herpetic eruption correspond to those which become tender in visceral disturbances in three points.

- 1st. They have the same distribution
- 2nd. They do not overlap
- 3rd. They have the same maxima.

Thus in the herpetic eruption I had a means of actually seeing the areas I was investigating, marked out for me on the surface of the skin.

## Conclusions

We have now been able with the help of traumatic lesions of the spinal cord to name each area according to the spinal segment to which it belongs. Thus the dorsolumbar area represents the supply of the first dorsal segment, and the gluteo-crural that of the first lumbar and each of the eleven intervening areas represents the supply of one segment whose number we now know.

In a similar manner we found that the gluteo-pudendal area represented the supply of the third sacral segment—the fibulo-dorsal that of the fifth lumbar and the intervening areas have been numbered according to the segments to which they belong.

We have also seen that the gap corresponds to the second third and fourth lumbar segments and we have been able from the lesions produced by organic disease to ap- proximately apportion the skin into areas corresponding to each of these segments.

## Introductory

We have now seen that the whole of the body and limbs can be marked out into areas, each of which I have attempted to show, corresponds to the cutaneous distribution of the pain fibres given off from one segment of the cord. I shall now try, and put before you the extent to which these areas are affected in diseases of the various organs.

It is a well known fact that the pain of visceral disease is not always localised by the patient over the organ affected. Ross first explained this fact by the ingenious hypothesis that the pain of visceral disease was referred along the distribution of the somatic roots which came off from the same level of the cord as the sympathetic fibres to the organs affected. He collected a large number of cases of pain, and his intimate knowledge of the sensory distribution of certain roots enabled him to say definitely that in certain cases, the distribution of the pain corresponded exactly with that of certain roots.

The description given by patients of their pain is, however, so unsatisfactory, that this important work did not bear fruit to the extent that might have been expected.

An enormous advance was made when Dr Mackenzie<sup>1</sup> described the cutaneous tenderness which is so frequently associated with the pain of visceral disease. For here we have a symptom which is distinctly more objective than that of pain only. He proceeded to collect a large number of cases in which the tenderness was present over one or more points, and in the course of this section, I shall repeatedly refer to his interesting paper. Although we worked independently and published at the same time, our results agree to an extent that is very flattering to me. In particular, I wish to emphasise the following points in which we are at one.

## §1 The pain and areas of tenderness in visceral disease, their characteristics and the means for their demonstration

In order to appreciate the characteristics of the areas of tenderness which appear in visceral disease it is best to take an example. In the type of case which is so common in our hospitals where a patient suffers from pain after food with or without hæmatemesis, an area of cutaneous tenderness is sometimes found which can be marked out as follows. The skin and subcutaneous tissues are taken up gently between the finger and thumb at various points on the abdomen.

Another method for bringing out these tender areas which is clumsy but theoretically interesting, is the use of a warm sponge or of a test tube filled with moderately warm water. As soon as the tender area is reached the patient experiences a feeling of great heat and flinches under the application. The same effect can be produced by moderate cold except that even moderate cold is at all times unpleasant to the skin of the abdomen, whilst moderate warmth is pleasant, and thus brings out the contrast between the normal and the altered sensory areas in a much clearer manner.

Another characteristic of these tender areas is the increased reflexes which can be obtained from them. This is a subject to which I shall return later but I may mention here that whenever a portion of the skin becomes hyperæsthetic from visceral disturbances the reflexes normally obtainable from that area are much increased. This is beautifully seen when the hyperæsthesia affects the skin of the abdomen or buttock on one side only, so that the reflexes on the two sides can be compared with one another.

A still better method of marking out such an area is to take a pin with a round head of such a size that it is obviously blunt to all parts of one's own cheeks and face. Travel over the surface of the abdomen using the blunt end only, in the same way as if you were using the point to test for analgesia. In a favourable case the patient does not complain until the limits of the tender areas are reached, when he at once complains that he is intensely sore and he will even cry out that you are pricking him. Thus in a favourable case the increased sensibility is so great that the contact of the blunt head of a pin is mistaken for a prick at the point. Subsequently in this paper this phenomenon will appear in my notes of cases as "head of pin called point."

In a large number of cases there is no such confusion but the patient says that, although he knows that the blunt end is being used it gives him great pain. He feels sore and bruised, as if he had been beaten about the body or back.

It is wonderful how unanimous patients are in their description of the sensation produced by touching such a tender area. I for one can fully confirm the description usually given by patients of their sensation. For such tender areas when touched, give exactly the sensation produced by touching a bad bruise. Many of my readers will have at one time or another suffered from these tender areas and will be able to bear out my description.

I must warn my readers from supposing that the patient cannot tell the difference between the head and the point of a pin on these areas. Far otherwise. The touch of the head of a pin feels to him like a prick on a normal skin surface, whilst the point gives him acute pain far in excess of that caused by a prick upon the normal skin.

FIG. 140B. Facsimile of excerpts from Head's original article.

[361]

### Conclusions

In this chapter I have described a series of areas which are tender in disturbances of the various organs. From the highest dorsal apex (dorso-cervical) I have traced 13 areas which fit into one another, and do not overlap to any appreciable extent. I have given cases of herpes zoster to show that the eruption in this disease appears over exactly the same areas as those which are tender in visceral disease.

We then passed to the buttock and the back of the leg, and marked out in a similar manner five areas belonging to the lumbo-sacral group. Between the lowest of the dorso-lumbar group and the highest of the lumbo-sacral set is a gap which is not affected in visceral disease. This gap I shall fill in in the next chapter with the help of organic lesions of the nervous system, and a few cases of herpes zoster.

Thus the gap in the arm which is unaffected by visceral disease probably represents the distribution of the pain fibres of the fifth, sixth, seventh and eighth cervical segments.

Thus we have now filled up the gap in the leg which is unaffected in visceral disease and seen that it probably represents the supply of pain fibres from three segments, the second, third and fourth lumbar.

Referred pain such as we have considered in this chapter is characterised by the following features:

- 1st. It tends to follow the lines of spinal segmentation rather than those of peripheral nerves. Thus on the chest it cuts across several ribs and does not follow the lines of any one intercostal space.
- 2nd. It tends to form bands round the body and thus in diseases of the abdominal viscera the pain may be quite as marked in the back as over the abdomen.
- 3rd. It is mostly associated with cutaneous tenderness, which may be quite as marked at a distance from the affected organ as in its neighbourhood. Thus gall stones are not only associated with tenderness over the area of the gall bladder in front, but also with tenderness over the ribs and spine behind. In the same way intestinal disorders may cause a band of tenderness extending round the body, not only in the loin but also overlapping the summit of the iliac crest on its way to the front.

I shall now give the limits of each area with its characteristics in detail, and in every case I shall give —

- 1st. The area of tenderness.
- 2nd. The maximum spots.
- 3rd. The position of the pain.
- 4th. The distribution of a case of herpes (when possible), which corresponds to the area described.

Though I give bony points as the guides to these areas, I must warn my readers that they are not absolute guides. For the only true guides to these skin areas are skin points, of which, unfortunately, there are very few. Thus the umbilicus is a much safer guide to skin areas than any bony point. Men, women, and children differ to such an extent from one another anatomically, that no actual measurement from, or dependence on bony points will give us the true nature of a skin area, and although its mutual relations render its nature obvious, we should go astray if we were guided by its relation to bony points.

### § 3 Topography

In the previous sections, I fear I may have led my reader to suppose that it would be an easy task to map out the areas of tenderness in visceral disease for the whole body. This is, however, not the case in practice. The first difficulty that meets us, is the only partial appearance of the areas in the forms of maximum tender spots. Now for these maximum spots to be of value, it is necessary that the whole area to which they belong should have frequently come under the notice of the observer, and yet it is only in a small proportion of the cases that he has the chance of seeing the area in its full development.

I have so far spoken as if a visceral lesion always caused tenderness over the whole of its appropriate area. This is not by any means the case. In disturbances of the stomach instead of a whole tender area such as I have described above, we frequently find two tender spots from an inch to an inch and a half in diameter situated over the costal margin at about the tip of the ninth rib, together with a posterior spot generally situated near the eleventh and twelfth dorsal vertebrae, a little to one side of the middle line.

Every such area of cutaneous tenderness has one or more maximum points, the position of which is exceedingly important, for it is to the situation of these maxima that the patient refers his pain. Thus in each case, given the position to which the patient refers his pain, I can say to what area the pain belongs. For I recognise in these points to which the pain is referred the maxima of an area whose limits I have occasionally found marked out by hyperaesthesia or analgesia, their limits never materially alter or overlap.

So fixed are these maxima, that supposing a whole area is tender, we can confidently predict that as the disturbance subsides, the tenderness will become limited to certain points, and when the disturbance has subsided still more, pain only will be left referred to the same points as the maxima. When I come to speak of the limits and relations of these areas, I shall therefore lay stress on the position of the maxima in each area as I describe it, for these maxima give us the clue to the meaning of pain referred to various spots on the body.

Now I was long ago struck by the fact that in affections of the peritoneum the pain and tenderness differed fundamentally from that of referred pain, in that, although the pain is well localised, it does not follow the line of the nerve areas. Thus, for instance, the patient will refer the pain to an area both above and below the umbilicus without at the same time complaining of any pain in the back or loin.

Moreover, there is no true cutaneous tenderness in peritonitis, and the tenderness that is present differs fundamentally in character from that which accompanies referred pain. If the skin only is picked up between the finger and thumb in a case of acute peritonitis the patient complains of no pain, but directly the deeper structures of the abdominal wall are included in the gentle pressure he complains of intense pain. Thus firm steady pressure as a rule relieves referred abdominal tenderness, whilst light pressure between the finger and thumb, or even the pressure of the clothes, at once elicits it. On the other hand in peritonitis light cutaneous stimulation causes no pain, but the slightest attempt at deep pressure, or even the lightest percussion, at once causes marked pain.

Again, the distribution of the two forms of tenderness differ fundamentally. The tenderness of peritonitis may be present all over the abdomen from the ensiform cartilage to the pubes and from one costal margin to the other, but it never appears at the angle of the scapula or over the sacrum and iliac crest. On the other hand, if referred tenderness extended over the area just mentioned, spots of tenderness would appear to a certainty over the ribs in the line of the angle of the scapula, over the costal margin in the eighth and ninth spaces, over the twelfth dorsal spine, over the twelfth rib, and over the last lumbar and first sacral spines. Thus the tenderness of peritonitis only makes its appearance over those points where pressure, &c., can actually affect the peritoneum, whilst referred abdominal tenderness is always present over bony points, where pressure cannot possibly produce any effect on the abdominal cavity or its contents.

Thirdly, we find that however great may be the pain caused by the peritonitis, the abdominal reflexes are not exaggerated as would have been the case if the tenderness had been cutaneous.

Thus in conclusion I think we can formulate the following statement: Affections of the serous cavities of the body do not cause referred pain or cutaneous tenderness, but produce local pain which follows the lines of peripheral nerves and is associated with deep tenderness over the affected point only.

Thus to sum up I think we may conclude that the central connections of the pain fibres from the skin and viscera are closely connected with one another. The central connection of the nerves for heat and cold, and for trophic disturbances in the skin must also be in somewhat close association, though probably not actually connected. On the other hand the nerves for touch from the skin (we do not know whether nerves for touch exist in the viscera) are widely separated centrally from those of pain. As to their paths in the cord I do not yet feel qualified to speak definitely.

FIG. 140c. Facsimile of excerpts from Head's original article.

from visceral diseases. Head also spoke freely of his reliance upon the papers of Gaskell concerning the distribution of visceral motor, and inhibitory fibers. Not claiming originality with regard to the already well known fact that visceral disorders caused surface changes, Head set about to utilize the work of these other investigators to accomplish his own primary object, namely to map out and to identify the surface areas related to the various segments of the spinal cord. Where the use of visceral disturbances failed him (silent areas or gaps) he turned to disorders of the spinal cord itself (compression myelitis, syringomyelia) and to those of peripheral nerves and nerve roots (severed fibers) to aid in the completion of his researches. Thus Head's great contribution was the positive identification of so-called cord zones (Head zones) upon the body surface.

With regard to diagnosis these pioneer studies left much to be desired and their results have not been so certain. Presenting a limited number of case histories Head reviewed all viscera in a systematic but somewhat sketchy fashion and gave no index as to which viscera in particular set up most clear cut evidences of referred surface phenomena. He also pointed out that given skin areas might be thrown into states of altered sensitivity from disorders of more than one viscus but gave no precise methods for dealing with the element of confusion which this overlapping introduced nor for identifying the particular viscus involved in a given case by means of sensory tests. Head's acknowledgment that surface sensory changes within cord zones were in some cases due to systemic disorders or to psychic states rather than to visceral diseases left the difficulty of differentiating these widely divergent causative factors. And the problems involved in determining how to utilize most effectively for diagnosis the cutaneous phenomena from visceral diseases remained, and to a considerable extent still remains, a matter for extended study and clinical investigation.

#### QUESTIONNAIRE

1. To what structures is the stomach attached?
2. Of what do gastric attachments consist?
3. What is an epiploon, an omentum, a mesentery? Derivation of words?
4. To what parts of the stomach are the gastric ligaments attached?
5. Compare the attachments of the adult stomach to those of the embryonic stomach.
6. Describe the lesser omentum; the hepatogastric ligament.
7. What structures are found between the peritoneal layers of the gastrohepatic omentum?
8. How can a liver abscess rupture into the stomach without invading the general peritoneal cavity?
9. Explain the occasional finding of toothpicks or sharp bones within liver abscesses.
10. Name the important structures found within the hepatoduodenal ligament. Give their relationships to one another and to surrounding structures.
11. Describe a surgical approach to the common bile duct.
12. What is the foramen of Winslow?
13. When small bowel becomes herniated through the foramen epiploicum what part of the constriction may the surgeon safely cut?
14. Name a safe method for liberating incarcerated intestine from the foramen of Winslow.
15. Describe the origin of the foramen epiploicum.
16. What is meant by the expressions greater and lesser peritoneal cavities or sacs?
17. Describe the relationship of important structures to the surgeon's finger after it has been introduced into the foramen epiploicum.
18. How does the surgeon locate the foramen of Winslow? Why does he examine this region of the peritoneal cavity?



19. What is meant by the following terms; omental bursa, Winslow's pouch, cavity of the omenta, retrogastric space?
20. Describe the origin of the omental bursa.
21. How do infections or infectious processes invade the omental bursa? How do foreign bodies penetrate into this space?
22. By what routes may the surgeon drain the omental bursa?
23. Describe the origin of the great omentum.
24. Describe the great omentum.
25. Trace the reflections of the peritoneum in the neighborhood of the stomach.
26. How many peritoneal layers enter into the formation of the great omentum; the transverse mesocolon; the lesser omentum?
27. Bound the omental bursa.
28. Name some of the surgical uses of the great omentum.
29. Describe the connections between stomach and diaphragm; stomach and spleen; stomach and pancreas.
30. What parts of the gastric wall are devoid of peritoneum?
31. Bound the uncovered or triangular area of the stomach.
32. Describe the gastroligament.
33. What important vessel courses within the left gastropancreatic fold; the right fold?
34. By what routes may the surgeon approach an ulcer situated upon the posterior wall of the stomach?
35. What are the advantages and disadvantages of the transgastric approach to the posterior gastric wall?
36. How may the posterior seroserous sutures be taken when closing a wound in the posterior gastric wall during the transgastric operation?
37. Describe one method by which stomach and proximal jejunum may be approximated for a gastrojejunostomy (posterior).
38. How is the rent in the transverse mesocolon dealt with at the completion of the anastomosis with a gastrojejunostomy?
39. Discuss bullet wounds of the stomach.
40. Should bullet wounds of the stomach be treated by immediate operation or by observation and palliation?
41. How frequently are other viscera injured when a bullet wound is inflicted within the stomach?
42. Define gastropnoia. State symptoms and treatment of this condition.
43. What is the normal position for the fasting stomach; for the stomach after a barium meal?
44. What percentage of all carcinomata involve the stomach?
45. How often, in examining patients with gastric carcinomata may a tumor be palpated?
46. Discuss the relative value of the physical examination and the history with patients afflicted with gastric carcinomata.
47. Does the absence of a palpable tumor exclude gastric cancer?
48. What factors mitigate against the finding of a tumor with gastric carcinomata?
49. In what topographical regions are gastric carcinomatous nodules or masses palpable?
50. Can a prognosis be ventured or definitely stated upon palpating a mass with cases of gastric malignancies?
51. Name the anatomical divisions of the gastrointestinal tract.
52. Give the boundaries separating various anatomical divisions of the gastrointestinal tract.
53. Describe the point of union of jejunum with ileum.

54. When is it important for the surgeon to definitely localize individual parts of the small intestine?
55. How may the operator determine which is the caudal and which the cranial end in an isolated intestinal loop?
56. What is the normal location of the vermiform appendix; variations from this normal position?
57. Name distinguishing points between upper jejunal and lower ileal segments of intestine.
58. What is a mesenteric cyst? Its composition?
59. Describe the signs, symptoms and treatment of omental cysts.
60. What is the sigmoid colon? the pelvic colon? the iliac colon?
61. What is a sigmoidoscope? How much of the lower bowel may be examined through this instrument?

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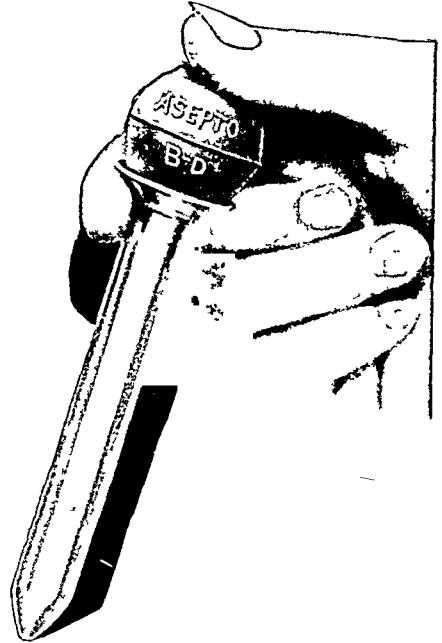
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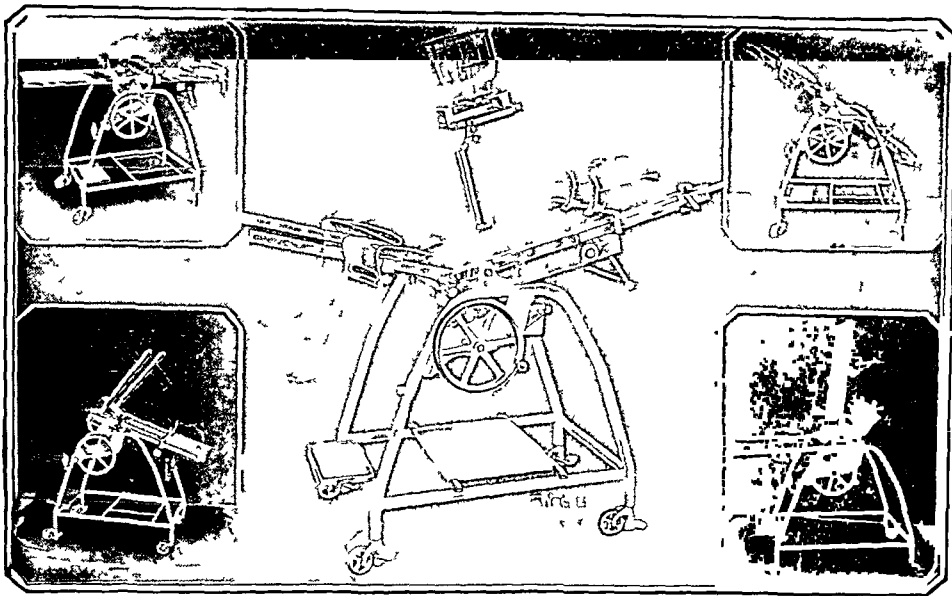
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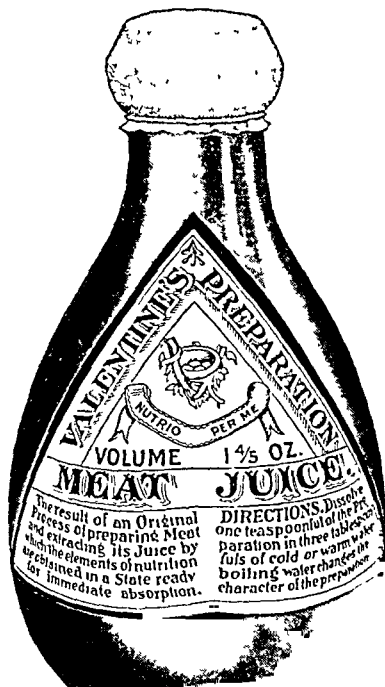
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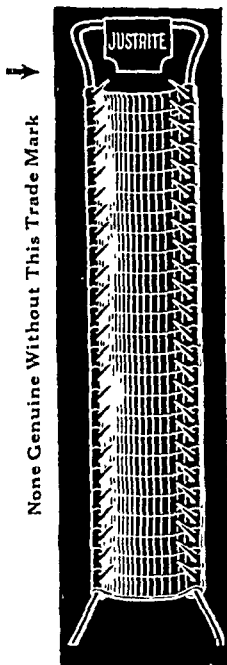
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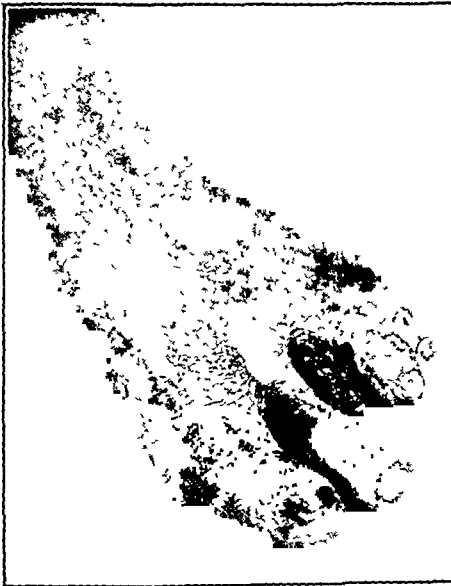
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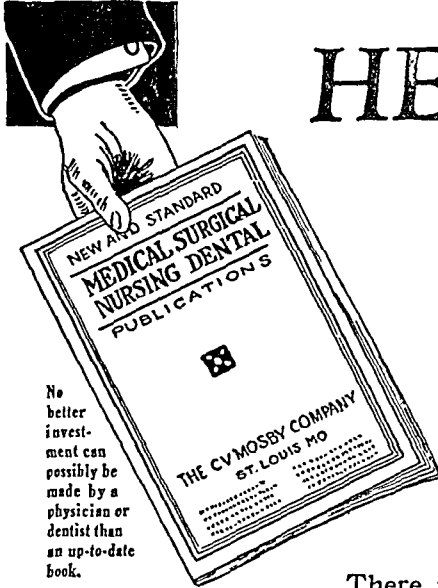
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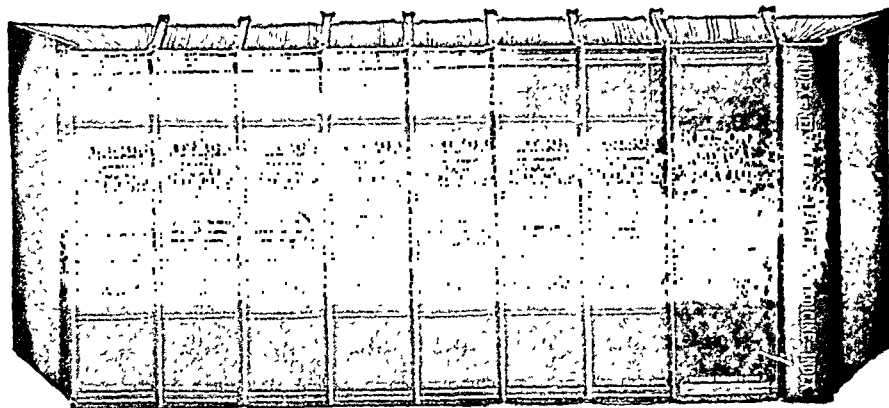
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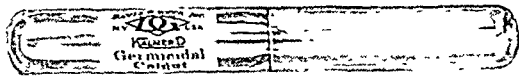
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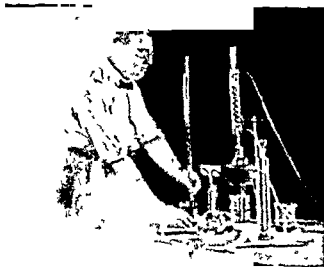


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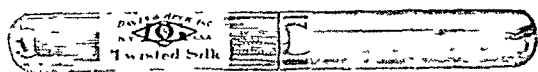


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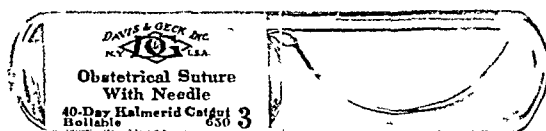
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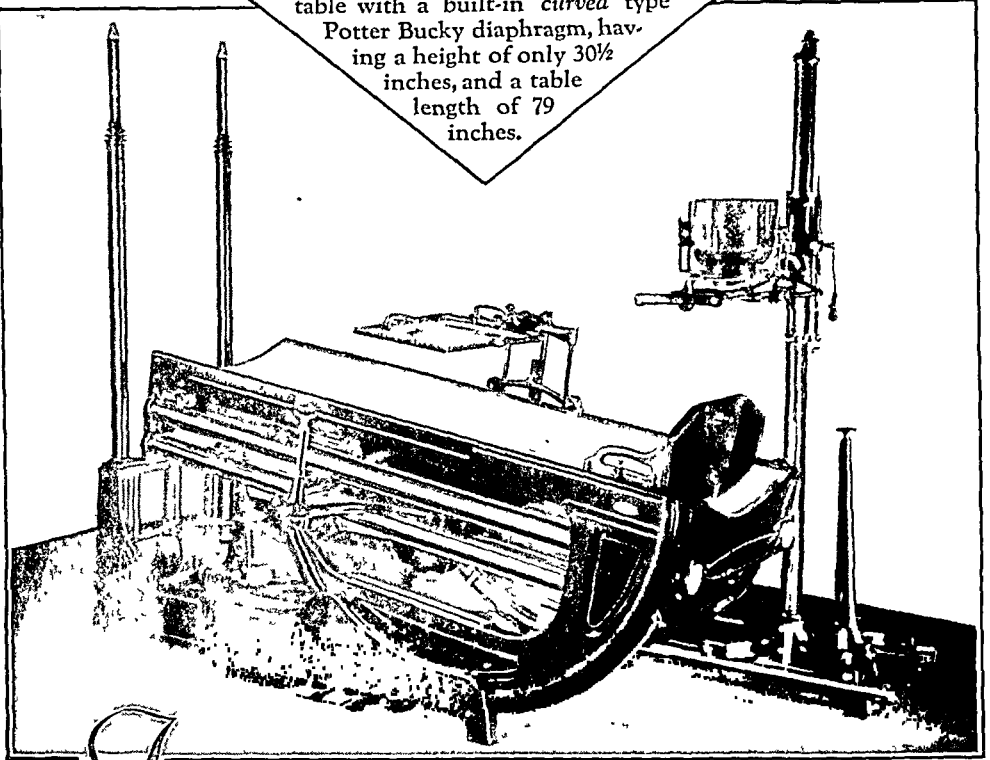
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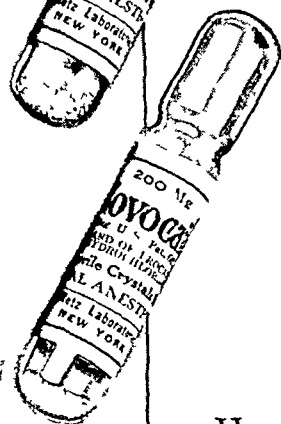
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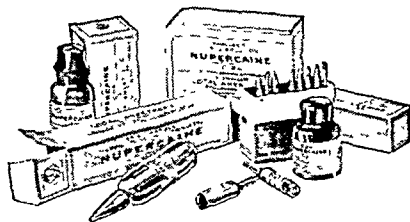
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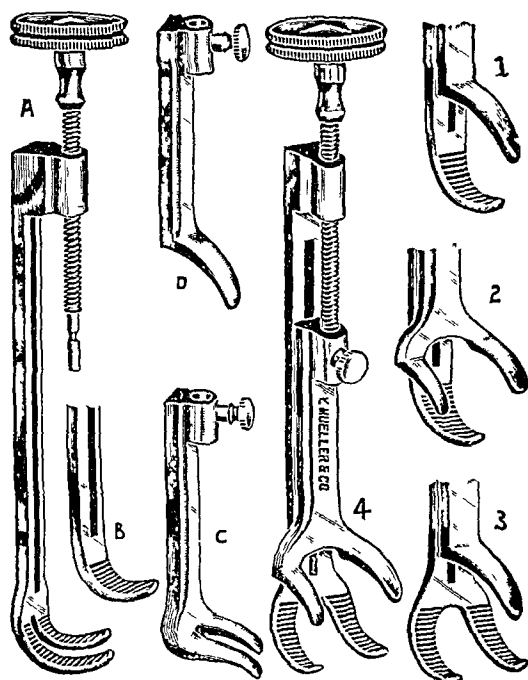
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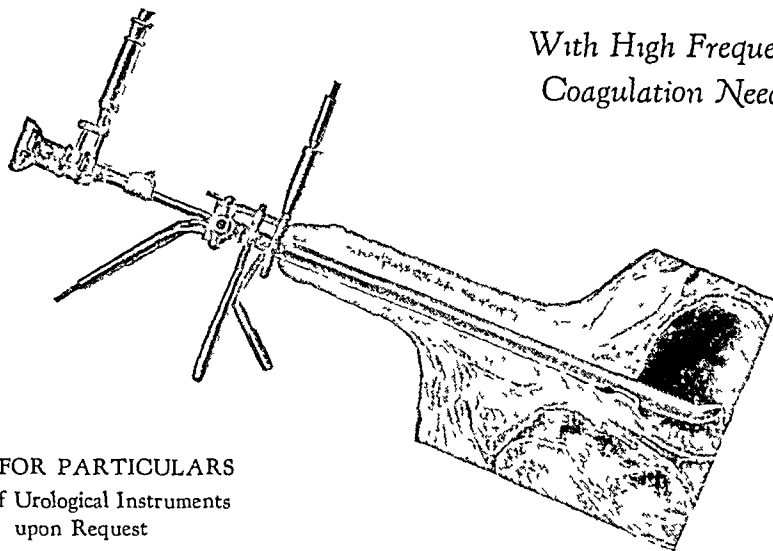
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## ACQUIRED CONTRACTURES OF THE HAND\*

SUMNER L. KOCH, M.D.

CHICAGO ILL.

**A**CQUIRED contractures of the hand, as distinguished from congenital contractures, may be due to a variety of causes, but by far the most frequent, in our experience, are infection and injury. Contractures due to infection and injury may be divided into several groups, corresponding to the anatomical part primarily and chiefly involved. They may be due essentially to a loss of covering tissue; they may be due to fixation of the tendons in scar tissue, or to contraction, division, or actual loss of the tendons; they may be due to perineural fibrosis, or to division of the peripheral nerves in the wrist or hand; they may be due to periarticular fibrosis or to fibrous or bony ankylosis; finally they may be due to an involvement of several or of all the anatomical structures which make up the intricate mechanism we know as the hand.

### CONTRACTURES DUE TO A LOSS OF SKIN AND SUBCUTANEOUS TISSUE

Such contractures commonly follow burns and crushing injuries. The essential factor in the treatment is the replacement of firm unyielding scar tissue by normal tissue from some other part of the body.

If the contracture involves the palmar surface of the hand it is usually possible, after complete excision of scar tissue, to cover the raw surface with a free full thickness graft, for as a rule, even after complete excision of contracting scar tissue one still finds a thin layer of tissue covering

the sheaths of the flexor tendons, the digital nerves and blood vessels. In such a case after all the scar tissue is excised, the

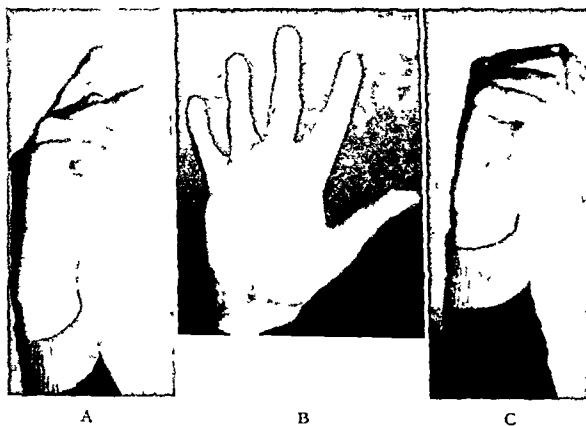


FIG. 1. Free full thickness graft.

(a) Position of fingers before operation showing marked limitation of extension.

(b) Appearance of hand three months after excision of contracted scar tissue and application of free full thickness graft. Although line of union of graft and skin can be clearly seen grafted skin is soft and supple, and matches well remainder of palmar surface.

(c) Restoration of flexion, as well as extension, is complete.

fingers are brought into extension, a pattern of the raw surface is made, and a free full thickness graft of the exact size of the pattern is taken from some other part of the body and accurately sutured over the defect.\*

\* We have also found the use of the free full thickness graft of value, as has Blair,<sup>2</sup> in the treatment of webbed fingers. When the fingers are completely and deeply separated a single pattern is made of the entire raw surface and a single free full thickness graft laid over the entire raw surface.

\* From the Department of Surgery, Northwestern University Medical School. Read before the Section of Orthopedic Surgery of the New York Academy of Medicine, December 20, 1929.

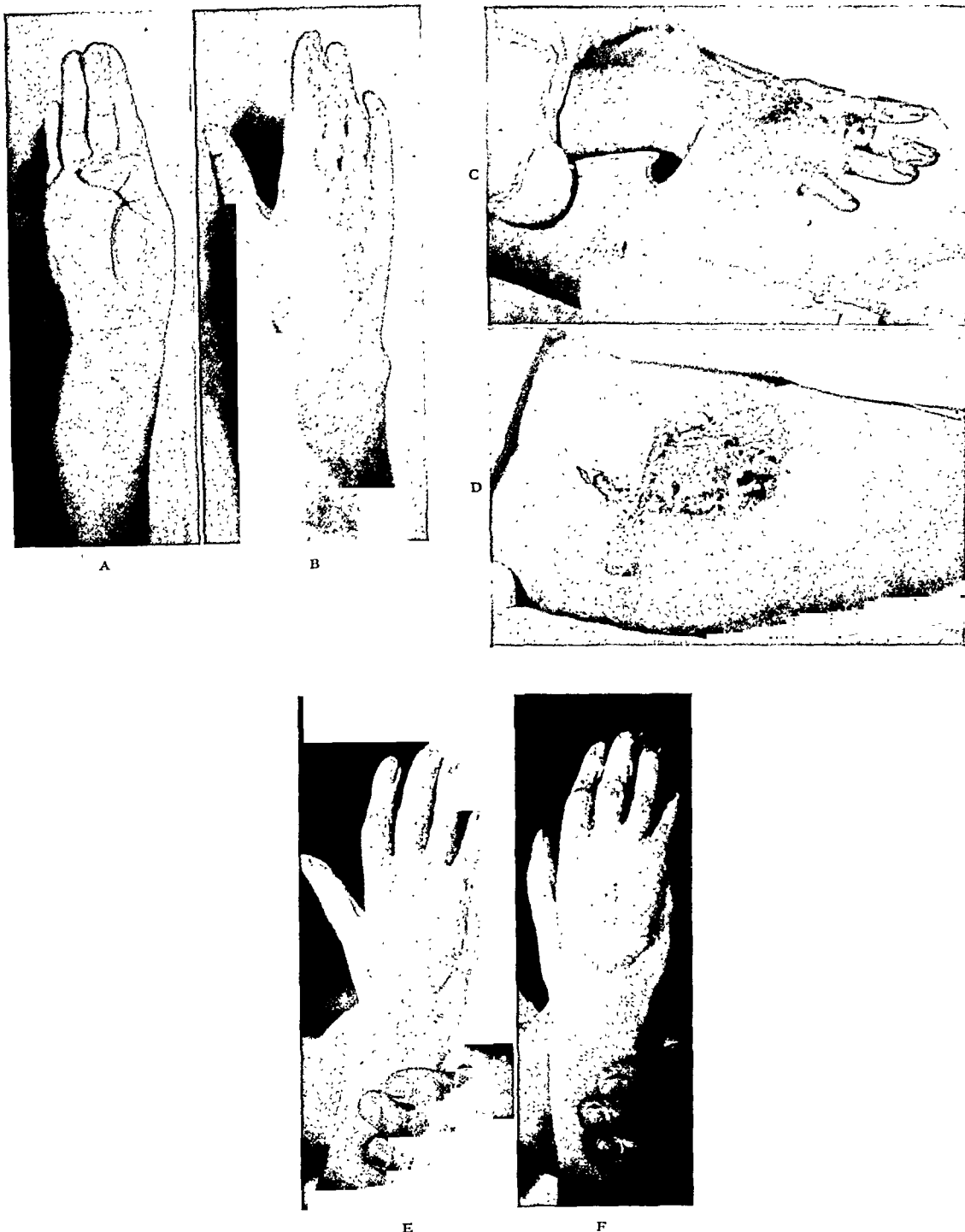


FIG. 2. Pedunculated flap for burn contracture of dorsum of hand and fingers.

- (a, b) Before operation.
- (c) Hand underneath flap raised from anterior surface of thigh.
- (d) Surface from which flap was raised three weeks after removal of flap, and two weeks after application of Thiersch grafts to raw surface.
- (e, f) Appearance of flap just after removal of sutures. (In this case there is complete bony ankylosis of metacarpophalangeal and proximal interphalangeal joints, which is still to be corrected.)

The technic of securing and applying a full thickness graft has been fully described, by Davis,<sup>1</sup> Blair,<sup>2</sup> by ourselves<sup>3</sup> and

tissue available for reconstructing the web of the fingers when the flap is sutured to the hand.

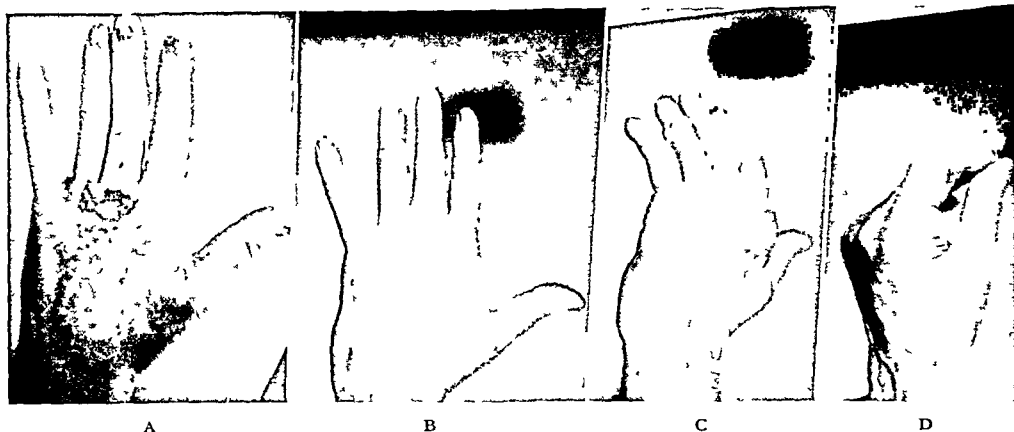


FIG. 3. Pedunculated flap for contracture and ulceration due to x-ray burns.

(a) Before operation.

(b, c, d) Four months after excision of scarred and devitalized skin, and application of pedunculated flap from right thigh.

by many others. An illustration of the results of the application of such a graft is shown in Figure 1.

If the contracture involves the interdigital space between the thumb and index finger, or the dorsum of the hand, a pedunculated graft is generally used, for on the dorsum of the hand even a superficial injury usually causes a destruction of all the tissues covering the tendons, and too often the tendons themselves.

Two methods may be used. If the defect to be covered is not too large the tubed flap is very satisfactory. It has the advantage of exposing a minimum area of raw surface to infection from the adjacent skin. If the defect is large and involves the dorsal surface of the fingers the part to be covered is placed under a pocket flap on the abdomen or thigh.\*

In placing the hand in such a pocket, a method which has been used and described by many surgeons, and which we have described recently in detail,<sup>3</sup> one should remember the importance of abducting the fingers as widely as possible from one another so that there may be sufficient

The results of the application of such a flap to the dorsum of the hand is shown in Figures 2 and 3.

#### CONTRACTURES DUE TO INJURY OF THE TENDONS

Injury of the tendons is one of the most common causes of contracture and at the

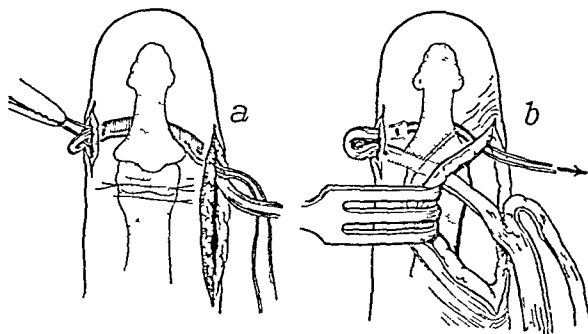


FIG. 4. Method of attaching tendon graft to the distal phalanx of finger.

same time one of the most difficult to treat with assurance of success.

Several types of tendon injury are of frequent occurrence in surgical practice. The simplest is that in which as a result of a crushing injury the tendons are contused and one or more of the metacarpal bones or phalanges are fractured. Usually there is no open wound. The hand swells

\* Blair<sup>4</sup> has emphasized the fact that the skin of the anterior surface of the thigh is thin and soft, and more nearly resembles the normal covering of the dorsum of the hand than the thicker skin of the abdominal wall.



rapidly because of subcutaneous hemorrhage and exudation. Because some of the bones are fractured the hand is immo-

heals active movement is attempted, and again one finds that the affected tendons are bound down by scar tissue and the power of movement is partially or completely lost.

If there is a serious infection of the tendon and tendon sheath the tendon frequently becomes necrotic, a part of it sloughs away and the wound heals only when all of the necrotic tendon is removed.

In the first type of case the best results are secured by instituting passive movements within forty-eight hours after the injury. If the hand and fingers are immobilized for several weeks the tendons become fixed, particularly within the tendon sheaths, and a certain amount of function is lost. Active, persistent and well directed physical therapy, in our experience, constitutes the most satisfactory form of treatment. To free the flexor tendons in the hand and fingers from the surrounding scar tissue by dissection with the hope of securing free movement has not in our hands given satisfactory results.

In the second type of case in which the tendon has been sutured and wound infection has taken place we agree with Bunnell<sup>6</sup> that careful and complete excision of the old tendon, and its replacement by a normal uninjured tendon from the foot give the most satisfactory result. In the third type of case, in which the tendon has been destroyed, replacement of the lost tendon by a normal tendon is the only treatment possible.

In substituting a tendon from the foot for flexor tendons in the fingers one of our problems has been to find a satisfactory method of attaching the new tendon to the distal phalanx. The method which we feel has given us the best results is illustrated in Figures 4 and 5. As a substitute for the flexor tendons of a finger, two tendons with their covering of gliding areolar tissue are taken from the dorsum of the foot. The free end of one tendon is then passed subcutaneously behind the distal phalanx of the finger in question,

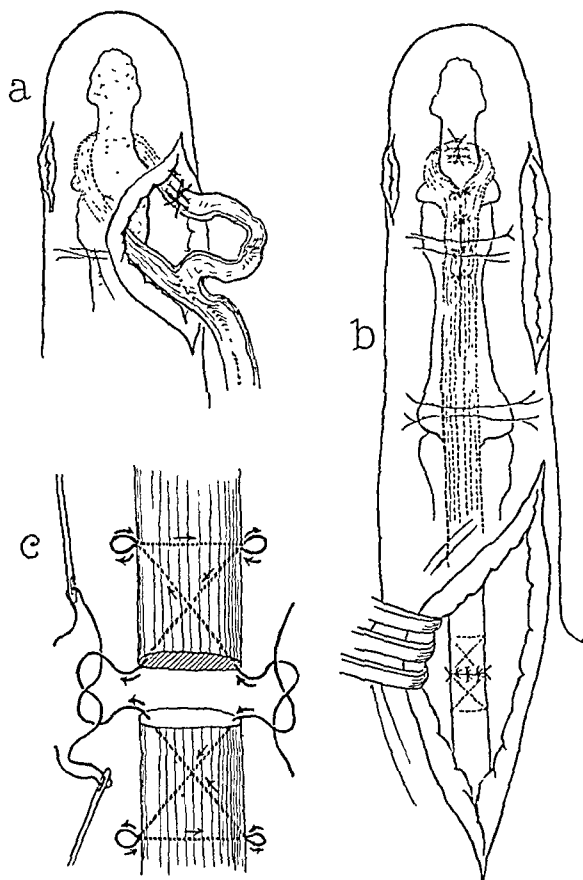


FIG. 5. Method of substituting two tendons from foot for flexor tendons of finger.

(a) Yoke method of attaching tendons to distal phalanx.

(b) Incisions and completed suture. (For clarity finger is shown extended; actually tendon is sutured under some tension and finger is flexed at all joints so that sum of angles of flexion at three joints amounts to approximately 90°.)

(c) Method of attaching tendon graft to flexor profundus digiti.

bilized,—too often for a considerable period of time. When attempts at active movement are begun one usually finds the tendons more or less completely fixed by fibrous tissue and flexion of the fingers definitely limited.

If there is an open wound with division of one or more of the tendons, usually a tendon suture is performed and, in a certain percentage of cases, wound infection develops. When the wound finally

and sutured to the free end of the other tendon. By gentle traction the suture line is brought over the middle of the

the tendons of the foot were substituted for the flexor tendons of the finger according to the method described.

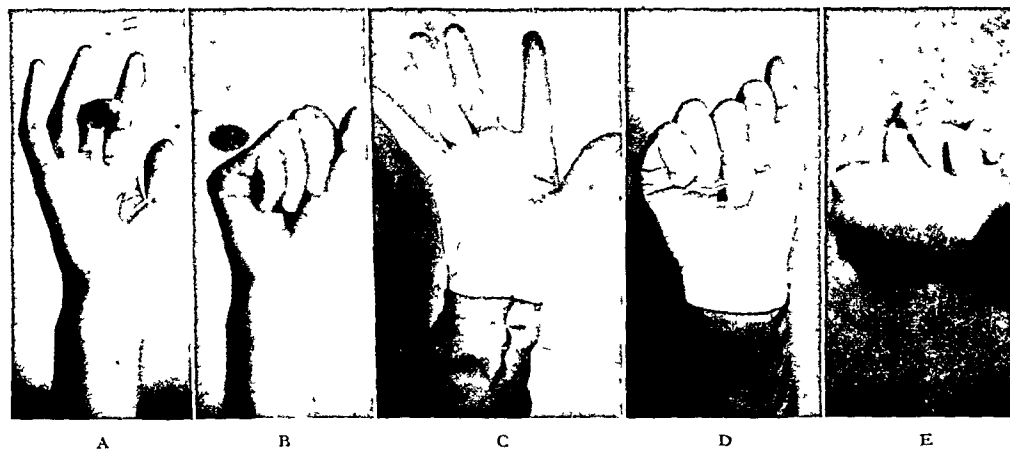


FIG. 6. Tendon transplantation, following complete loss of flexor tendons in middle finger after suppurative tenosynovitis.

- (a) Limit of extension before operation.
- (b) Affected finger can be flexed because of action of intact lumbrical muscle.
- (c) Extension possible after tendon transplantation. (In this case after excision of scar tissue remaining at site of tendon and its sheath finger could be extended with little difficulty, but there was a skin defect, roughly triangular in shape and half the size of a postage stamp, over proximal interphalangeal joint. After tendon transplantation this raw surface was covered with a free full thickness graft, as it was impossible to approximate skin edges with finger in extension.)
- (d) Flexion possible at all joints after tendon transplantation.
- (e) Flexion possible at distal interphalangeal joint.

distal phalanx, and lies well covered by the soft tissues on the dorsum of the distal phalanx. The collar or yoke thus formed about the distal phalanx gives an excellent

#### CONTRACTURES DUE TO PERIPHERAL NERVE INJURY

The treatment of contractures due to peripheral nerve injury is too well known to

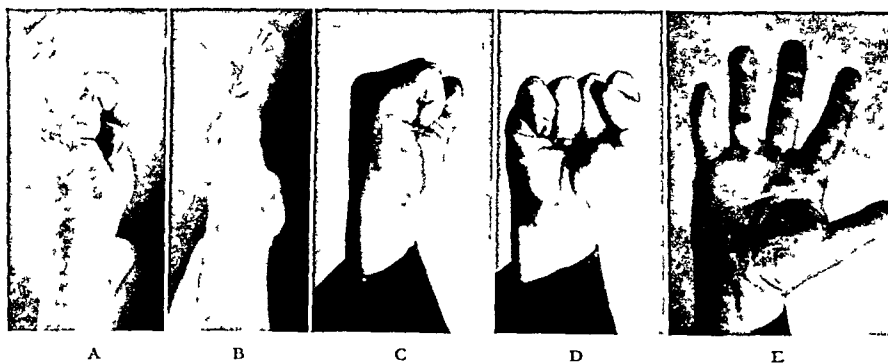


FIG. 7. Division of collateral ligaments of metacarpophalangeal joint for limitation of flexion of fifth finger. (This patient's little finger had been fixed in extension for several weeks after a fracture of metacarpal bone.)

- (a, b) Before operation.
- (c, d, e) After operation.

Note distance between tip of little finger and palm in (a), and improvement in (c), due almost entirely to increase of flexion at metacarpophalangeal joint.

distal attachment or insertion for the transplanted tendon. Figure 6 shows the results of operation in a case in which

require more than a brief mention. The only logical method of treating nerve division, we believe, is by excision of the

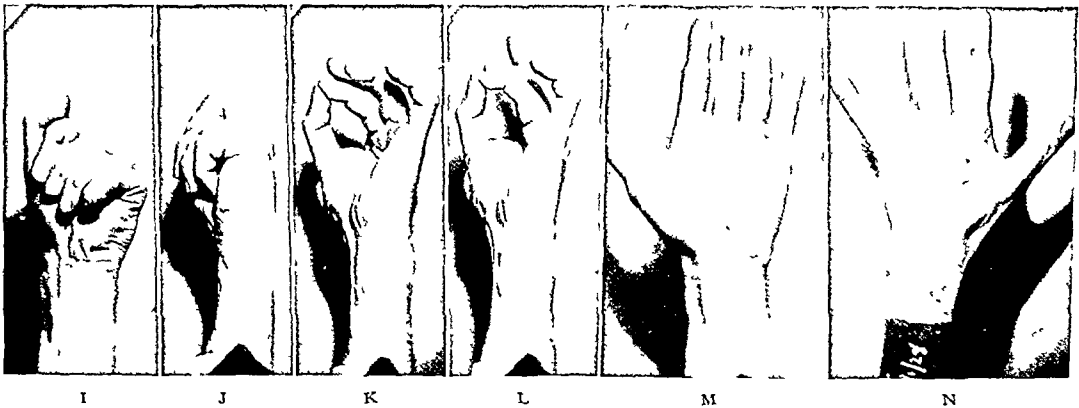
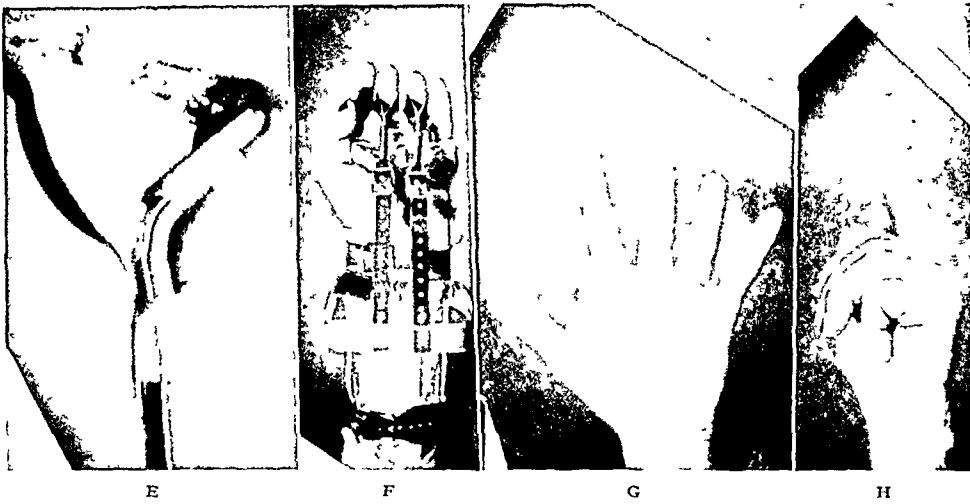
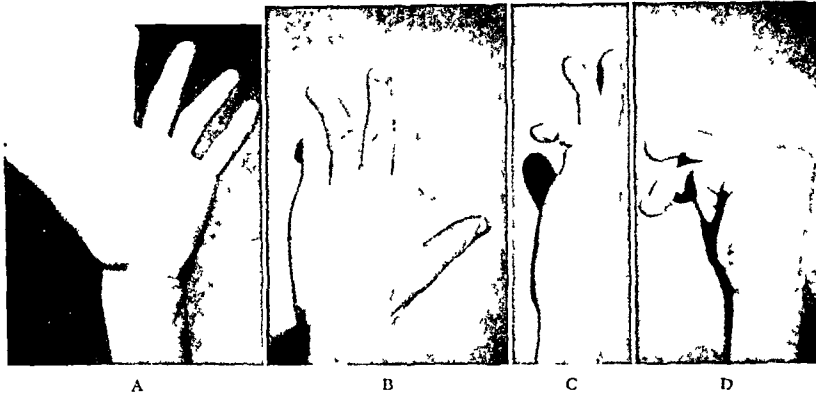


FIG. 8. Arthroplasty for bony ankylosis of proximal interphalangeal joints of middle and ring fingers. (This patient, a violinist and teacher, had sustained a saw-cut across dorsum of fingers in a manual training laboratory.)

A, B, C, D. Before operation.

E, F. Method of splinting after operation. G, H. Result four weeks after operation.

I, J, K, L, M, N. Result six months after operation.

neuromata, and careful end to end suture of the divided nerve by uniting the nerve sheaths of the proximal and distal segments with fine silk sutures.

#### CONTRACTURES DUE TO PERIARTICULAR FIBROSIS AND TO ANKYLOSIS

Contractures due to periarticular fibrosis and to fibrosis and bony ankylosis are common and are frequently neglected. Two types are worthy of special mention. The fixation in extension that occurs, particularly at the metacarpophalangeal joints, as a result of shortening of the collateral ligaments, while the fingers are kept immobilized in an extended position has been described by Shaw<sup>6</sup> and later by Glissan.<sup>7</sup> To the best of our knowledge Shaw was the first to call attention to the fact that the shortened collateral ligaments constitute the most important factor in fixing the fingers in the extended position and that subperiosteal separation of the origin of the ligaments from their proximal attachment permits relaxation and flexion of the stiffened joints.

If bony ankylosis is present arthroplasty is the treatment of choice. Nowhere, in our observation, does arthroplasty give more satisfactory results than at the wrist joint and at the small joints of the hands. At the wrist joint satisfactory results are obtained only if sufficient bone is removed. In our earlier cases we failed to secure a complete range of movement because we removed a layer of bone approximately a half inch in thickness. Of late years we have removed almost twice as much, and with definitely improved results.

Figure 7 shows the improvement obtained in flexion of the little finger by detaching the collateral ligaments from the head of the fifth metacarpal bone, and Figure 8 the result secured by arthroplasty at ankylosed interphalangeal joints.

#### SUMMARY

Contractures of the hand due to injury and infection may be divided into several

groups, in accordance with the anatomical part chiefly involved. Whether skin and subcutaneous tissue, tendons, nerves or joints are chiefly involved definite improvement can frequently be secured by well directed and carefully executed operative procedures. Of these the most important are transplantation of skin by the use of the free full thickness graft and pedunculated flap, tendon transplantation, division of the collateral ligaments of the small joints of the hand and arthroplasty.

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#### DISCUSSION

DR. HUGH AUCHINCLOSS: Reconstruction work on the hand is difficult enough, but reconstruction of the fingers is far more difficult.

I am sure that we all agree with Dr. Koch that the use of pedunculated grafts and whole thickness grafts is most desirable. If care is taken to remove the fat from beneath whole thickness grafts, nearly all of them will take, provided gentle pressure, freedom from hemorrhage and lack of tension obtain.

It might be wise to distinguish between webbed fingers and fused fingers. Free use of rather thick Thiersch grafts is most desirable if there be any tension, and grafts are excellent for making webs at the base though triangular flaps slung from the dorsum also serve the purpose very well.

Where there has been infection, it is frequently better to use Thiersch grafts to secure immediate healing of defects with the idea of subsequently excising them if necessary and replacing them by whole thickness grafts weeks or months later, when all danger of infection has passed.

To secure motion in a finger where the joints have been preserved but the tendons have sloughed or become adherent, is a fascinating problem and one that so far has not yet been definitely agreed upon by all operators. I must confess that I do not know which of the several different methods is the simplest and best. In my experience the dissection free of an adherent tendon has not been successful. Some form of transplantation must be resorted to. Transplantation of one of the extensor tendons from the foot with its sheath as advocated by Dr. Bunnell, I have done successfully and believe it to be a very good method, but it is technically a difficult procedure. The last few years I have been using transplantations of a portion of the palmaris longus tendon and transplantations of the tensor fascia femoris from the thigh, in both instances preserving the delicate paratendinous tissues. In making such transplantations, there is always the difficulty when sutures are used that the silk sutures will tear out if motion be resorted to early. For this reason I have used very fine artery clamps that have been sharpened to a point so that the sides have a cutting edge. These little instruments permit one to weave tendinous or fascial strips of small size into the periosteal attachments of divided tendons and into the tendons themselves with considerable ease and make what is often a very difficult technical operation much simpler. One of the great difficulties is to provide phalangeal annular ligaments where they have been destroyed so as to prevent tendon prolapse. If the flexor sublimis tendon has its dividing slips along the side available, it is possible to use these. If not, it may be necessary to transplant fascia.

In doing this delicate type of surgery, it is of great advantage sometimes to use magnifying lenses. I have used large magnifying glasses such as reading lenses, but more recently have constructed with a metal frame, so that they can be sterilized, a pair of glasses provided with two magnifying prisms attached by means of an extension to the frame called a Loupe by the oculists. They greatly aid in the recognition of finer structures.

Transplantation of fatty and areolar tissue, especially from along the outer part of the thigh is very useful, particularly about the tendons in the hand.

With reference to arthroplasty of the phalanges, the interposition of fascia, provided enough bone is removed and the cartilage has

been entirely lost from the two bones involved, may be of use. Nothing, however, is better than cartilage itself and where one bone involved retains its cartilage, no fascia is necessary. In a recent case, where fibrous ankylosis had taken place between the two proximal phalanges, a portion of bone was excised, the distal end of the proximal phalanx was rounded off and a concavity was bored with a Hudson drill in a costal cartilage in the center of a button that had been cut by means of a trephine. When the button was removed it was possible to round off the convex surface so as to make it resemble the shape of the head of the bone and this little cartilaginous cap fitted nicely over the rounded shaft of the proximal phalanx. The operation was done through a longitudinal incision in the middle of the extensor tendon and motion has been obtained, but there has been some lateral deviation due to the absence of the collateral ligaments. If this be tried again, I shall arrange to leave a little of the sides of the cartilaginous cap cut away so that scar tissue attachments between the side of the bones can take place and serve as lateral ligaments.

DR. HENRY W. CAVE: For many years while working in the Dispensary at Roosevelt Hospital I have been forcefully struck by the great number of deformities that follow acute infections of the hand. These deformities seem almost beyond the stage of any remedy. I should like to take this opportunity to emphasize the importance of the removal of both rows of the carpal joints in those patients that have complete ankylosis. They are the most difficult cases that we have to deal with in late results following infections of the hand.

Physiotherapy has given us excellent results.

How long does Dr. Koch carry out physiotherapy and keep up elastic tension before resorting to operative methods?

Recently I had under my care two trained nurses with ankylosis of the metacarpophalangeal joints. Fortunately, I got them early enough, so that with well directed massage and physiotherapy they both are getting good results, and I do not believe that an operative measure will be necessary. One of them had marked ankylosis of the middle, ring and little fingers. I loosely applied elastic tension, and was able to draw out these three fingers into practically a straight line with complete flexion and extension.

DR. A. R. MACAUSLAND: The courage that

is necessary to follow through this sort of work and get results cannot be appreciated by anyone who has not been confronted by a number of such cases. The contracture deformities and loss of function due to damage of the deeper structures, we, as orthopedic men, are familiar with. I hope to seem more of the tendon grafts done and hope to see more success, but my work in that particular field has been discouraging.

In regard to nerve suture, there is little question but that early nerve suture is the only way to get a highly satisfactory result; the later it is done, the less satisfactory.

In grafting the nerve, little has been accomplished. I have seen and followed through a great many cases, and have not seen a single one the slightest encouraging. The oldest case I had a chance to follow up was a soldier in the Boer War, who had a graft with a rabbit's nerve and that did not show anything at all. One would not expect it to do so. I have had the pleasure, however, of dissecting the section of that particular nerve and having it examined, and excepting for the ordinary scar tissue there was nothing extraordinary in the nerve bulb at the end of the ulnar nerve. So I do not expect that nerve grafts are going to succeed unless some one develops an extraordinary technic. In joints, however, we are improving all the time. Long ago there were very few who attempted arthroplasty, but now many are doing them. The larger joints are the easier ones. The value of early mobilization was emphasized by Dr. Koch, and while I agree that the large resection of bone assures a little more certainty of a mobile wrist, I do not think it is entirely necessary for success. Resection of a joint does not constitute a true arthroplasty, although such an operation may be very successful in mobilizing the joint. We believe that motion and stability can both be obtained by proper operative technic.

DR. LEO MAYER: When I was talking to Dr. Carrel a few years ago, he told me that he considered reparative work on the fingers the most difficult in all surgery; transplanting of the kidney was a little thing compared with repairing a damaged finger.

I wish to talk about tendons and nerves; first, free nerve transplantation. I have done 6 cases, 4 for the musculospiral nerve in war injuries, where a large portion of the nerve was shot away and it was impossible to get end to end apposition. In 2, perfect restoration of

function resulted; in these, I used a cable graft, about 4 in. long, employing the external saphenous nerve in 1 case and the radial nerve in the other. In 2 cases I did the same operation for a long gap in the ulnar nerve and in 1 there was perfect restoration. In other words, of 6 cases 3 had return of normal function.

DR. MATHER CLEVELAND: The surgery of the upper extremity is the surgery of the hand, to preserve or restore to the individual the prehensile and tactile fingers. Many of the cases that Dr. Koch presented emphasized the fact that hand infections are still treated badly in the beginning.

It has been our endeavor to teach our medical students intensively as Dr. Auchincloss taught us the importance of hand infections, recognizing them early and draining them accurately and adequately in the beginning. Attention to this would do away with the necessity for much of this reconstructive surgical work.

It is important to appreciate the fine details of the anatomy of the hand in order to do this type of surgery properly. One of the most crippling injuries we see is that due to division of the deep branches of the ulnar nerve, with paralysis of the lumbricales and interossei muscles.

In a case of Dr. Krida a large part of the disability is due to the intrinsic muscle paralysis. It is very disconcerting to adequately drain an infected ulnar bursa and in doing so divide the deep branch of the ulnar nerve. This nerve and the branch of the median to the thenar muscles are unfortunately injured in palmar incisions placed without due regard to the anatomy of the region.

I am much interested in webbed fingers and in the method of repair used by Dr. Koch. In the treatment of this condition the important factor is to get good skin at the bottom of the web, and you get that in congenitally webbed fingers by turning down from the dorsum a triangular flap of skin from the web and suturing it into the defect. On the sides may be placed full thickness or Thiersch grafts; but unless you get the bottom of the cleft covered with skin, your web operation will not succeed. I should like to ask how Dr. Koch prepares the skin. I am sorry he did not mention Dupuytren's contraction.

DR. J. H. GARLOCK: In the presentation of Dr. Koch's cases of scar contractions of the palm, it was to be noted that the majority of them were corrected by the application of free

full thickness skin grafts following excision of the scar. It has been my experience that the majority of these cases need more tissue than is obtained by free full thickness skin grafts in this situation. Only in an occasional case have I found it feasible to make use of this valuable type of skin grafting. In the majority of instances, I have found it necessary to add subcutaneous tissues as well as skin, and have accomplished this by the use of pedunculated skin flaps in the form of the tubed variety. This method seems so far the most ideal inasmuch as the possibility of contamination and infection is reduced to the minimum. Following the application of such pedicled flaps, it is extremely important to apply an immobilizing spica made of plaster. The arm must be held in position so that the slightest degree of movement is avoided. This can only be done by the use of a plaster cast. I have seen disastrous results follow when this precaution is not taken.

As regards free tendon transplants, the gliding mechanism originally described by Mayer and Biesalski must be taken into consideration. It seems unnecessary and hardly feasible to graft a tendon with its surrounding sheath. A tendon with its surrounding peritenon seems to be the best available tissue for this purpose. Following the insertion of a free tendon graft in the finger proper, it is important to make sure of the presence of vaginal ligaments in order to maintain the finger's mechanical efficiency. Numerous methods for the duplication of these vaginal ligaments have been tried. So far, I have found the most satisfactory ones to be a free tendon graft placed sling-like around the new flexor tendon and the phalanx so as to encircle both structures. Three of these are inserted, one in the region of the middle phalanx, a second about the proximal phalanx, and the third about the head of the metacarpal bone.

The subject of nerve grafting is a very difficult one. I believe that probably the most difficult operation in surgery is that of inserting cable grafts to bridge a defect in a nerve. I have done this operation a few times with very questionable results. One point is certain. It seems absolutely necessary to have a scar-free bed in which these grafts may be placed. Otherwise the contraction of the scar will result in the early strangulation of the nerve grafts. Stookey has emphasized this point. In the treatment of stiffened metacarpophalangeal joints, I find that a great deal can be accom-

plished by continued elastic contraction and that cutting of the accessory ligaments should be done as a last resort.

Finally, I believe that a word of warning is in order. Reconstruction surgery of the hand must not be undertaken too lightly. It is a very difficult branch of surgery, and is one that is filled with many disappointments and unexpected sequelæ. The surgeon must evolve for himself an operative technic which is well-nigh perfect and which is always cognizant of microscopic trauma. I have found the Beebe-Loup magnifying eyeglass of great help in striving for this minimal tissue trauma.

DR. KRIDA: I was very much impressed by Dr. Koch's preliminary skin graft, particularly the full thickness free skin graft, in those cases where a subsequent reconstructive operation on the tendon was indicated. I should like to ask how long after such a graft has been applied can one proceed with the incision of the graft and reconstruction of the underlying tendon.

DR. KOCH, *closing*: Dr. Auchinclos mentioned the importance of covering large raw surfaces on the upper extremity as early as possible with Thiersch grafts. Their value has also been emphasized by Lyle, who pointed out the fact that such grafts lessen the amount of cicatricial contraction and remove the danger of reinfection constantly present in the presence of an open wound.

Dr. Auchinclos asked what method we have used to restore function and the power of flexion if the flexor tendon has been infected. After a severe infection the tendon is usually lost. There remains, however, dense scar tissue at the site of the tendon and its sheath. It has been our custom to dissect out the scar tissue before transplanting a tendon graft. We have not tried the method of introducing a tendon blindly through a small tunnel for we fear it would not move freely in such a tunnel, but become adherent to the surrounding scar tissue.

When the scar tissue has been completely excised along the course of the tendon and the graft has been placed in position one must reconstruct one or more annular ligaments to prevent the tendon from being lifted away from its bed when the finger is bent in flexion. We do not know what is the most satisfactory method of forming such ligaments. We have used pedicled strips of fibrous tissue dissected from alongside the tendon and laid transversely

across the tendon and thin strips of tendon completely encircling the bone.

Dr. M. L. Mason in his experimental work at Northwestern University Medical School on the transplantation of tendons has concluded that the transplantation of the tendon sheath or the gliding tissue about the tendon is an important factor in securing a successful result. Bare tendons do not easily become vascularized, and they tend to become firmly adherent to the surrounding tissues.

I was much interested in the idea of transplanting cartilage into a joint, and shall be interested to know the final result. I recall a patient seen recently in whom the entire proximal phalanx of the thumb was removed because of a giant cell tumor. A piece of rib cartilage was substituted for the removed phalanx. One year later the cartilage had almost completely disappeared.

Dr. Cave asked how long one should continue physical therapy before resorting to operation upon stiff metacarpophalangeal joints. It seems to me that it depends upon the rapidity of improvement. I saw a patient a few days ago who had been operated on for a Dupuytren's contraction and was left with stiffened fingers and hand. We sent her to the physical therapy department and did not see her for two weeks. At the end of that time there was so definite an improvement that we concluded that she would probably secure complete restoration of function if she continued with the treatment. If the fingers are held fixed in extension at the metacarpophalangeal joints, however, I would not hesitate to cut the collateral ligaments.

When I spoke of wide resection of the bone in cases of ankylosis of the joint, I was not speaking of all joints, but only of the wrist joint. I have had no experience with resection of the elbow joint and could not express an opinion as to arthroplasty upon the elbow joint.

I was very much interested in the results Dr. Mayer reported in his cases of nerve transplantation. In some experimental work recently performed at Northwestern University it was shown that nerve fibers will grow down into nerve transplants, but that very few fibers

will continue through the transplant into the distal segment of the nerve. Their downgrowth is apparently checked by the fibrous tissue which forms at the distal line of suture. That Dr. Mayer was able to secure successful results in 50 per cent of his cases is extremely interesting.

Dr. Cleveland spoke of the importance of correct surgical treatment of infected hands. I agree absolutely that if cases of infection were properly treated many of the surgical procedures discussed here this evening would be unnecessary. We have been trying in Chicago to teach to every class of students that is graduated from the medical school the principles of the surgical treatment of infections of the hand, as they have been set forth by Dr. Kanavel. We feel the importance of this subject in the surgical curriculum needs to be constantly re-emphasized.

Dr. Cleveland is quite right about the treatment of webbed fingers. If one can get normal skin at the bottom of the interdigital space any remaining defect can be covered with a graft. In suggesting the use of a simple free full thickness graft extending upward on the side of one finger and downward on the opposing side of the adjacent finger I had in mind particularly those cases in which the adjacent fingers are held tightly together, and there is no redundant tissue whatever.

In preparing a hand for operation it is washed with soap and water for twenty minutes the evening before operation, and then wrapped in a sterile dressing. Just before the operation the hand is painted with 5 per cent picric acid in 95 per cent alcohol.

The treatment of Dupuytren's contraction is a long story. A paper giving the results of our experience was published in *Surgery, Gynecology and Obstetrics* in February, 1929.

Dr. Krida asked how soon after transplanting a flap one could perform the secondary operations necessary. We like to wait three months after healing is complete so that we may be certain there are no bacteria deep in the tissues. If we have primary union of the transplanted flap we sometimes operate at the end of two months, but we prefer to wait for three months if possible.



# COMPRESSION FRACTURES OF THE SPINE

## LATE RESULTS IN CONSERVATIVE TREATMENT OF UNCOMPLICATED CASES\*

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**I**N view of the fact that there exists some diversity of opinion in regard to the best method of treatment of uncomplicated compression fractures of the spine, the writer ventures to report the present small series which seems to afford very favorable evidence in behalf of the conservative treatment in contrast to the operative treatment.

Compression or crush fractures of the vertebrae are attracting more interest of late because of their frequent occurrence and because they are often unrecognized. In a series of 400 spinal injuries Sante and McCutcheon<sup>1</sup> found that 40 per cent were compression fractures and, moreover, that of these compression fractures 80 per cent were between the tenth dorsal and the third lumbar vertebrae. These writers emphasize the necessity of making both anteroposterior and lateral roentgenograms and call attention to the need of differential x-ray diagnosis between tuberculous spondylitis, hypertrophic spondylitis, pyogenic infection of the spine, Charcot's spine, malignant involvement, and pressure destruction of the vertebrae. According to Osgood<sup>2</sup> 50 to 60 per cent of compression fractures involve the twelfth dorsal or the first lumbar vertebrae.

The etiological mechanism in these fractures is hyperflexion of the spine, which occurs particularly in falls. Of late it is more common in women because of automobile accidents. Verneuil<sup>3</sup> reported a case of compression fracture due to muscular action in a patient who made a successful attempt to escape a fall on the ice. The writer is now taking care of an elderly woman with compression fracture of the first lumbar vertebrae which resulted merely from a fall down two marble steps. In a series of 90 spine injuries Stewart<sup>4</sup>

found that 42 per cent of the compression fractures had been unrecognized.

Brown and Brown<sup>5</sup> report the case of a compression fracture in a thirteen year old girl, whose back was hurt on a slide and who went on a hike three hours afterward. These writers note that many patients do not consult a physician until three months after the injury.

Mill<sup>6</sup> reports the case of a compression fracture in a girl of seventeen from a very slight trauma while at play and which was due to strain in a moment of relaxation.

In 1895 Kummel<sup>7</sup> reported serious late results in these cases. As Kummel has shown<sup>8</sup> the wedge-shaped deformity of the vertebra may develop in the absence of typical x-ray findings at the original examination. Kummel's disease is the painful back with wedge-shaped deformity of the vertebra which develops in cases where there has been an absence of a clinically demonstrable lesion after a fall.

While it is often possible to reduce the deformity fairly well, late x-ray studies are apt to show its persistence. Rogers<sup>9</sup> goes so far as to say that "with the most careful treatment and protection possible he has never seen an x-ray examination in the later stages that did not show a greater amount of wedging than was shown in the early x-ray study." (Compare Figs. 1, 2, and 3.)

Until recently attention was directed chiefly to the avoidance of weight bearing and to fixation of the spine in the treatment of these cases. Stewart<sup>10</sup> recommends three months in bed followed by six months in a brace. Brown and Brown<sup>5</sup> place their patients in extension for two months and follow this with a brace or cast for six to twelve months. Rogers<sup>9</sup> uses a plaster shell

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for six weeks and places the time of average recovery at six months. Eikenberry<sup>11</sup> keeps his patients in bed on a convex

old cases conservative methods are to be tried first.

In recent years more stress has been



FIG. 1. J. E. October 31, 1928, date of injury, showing compression fracture of first lumbar vertebra.



FIG. 2. One week after injury showing reduction of fracture of first lumbar vertebra. Compare with Fig. 1.

frame for three months and uses a spinal support for nine months more. This writer, who reviewed 131 cases of compression fractures of the vertebrae, states that if a plaster shell is used, it should extend from the head to the knees and that healing requires six to eight months. Scudder<sup>12</sup> advises correction by hyperextension and support for about six months. He believes operation to be unnecessary. Osgood<sup>13</sup> who is a strong advocate of the non-operative treatment advises recumbency in hyperextension for six to eight weeks. The upright position is then gradually assumed and a spine brace is worn for ten to sixteen weeks. In the last five to six weeks Osgood advises physical therapy and says that a full cure may be expected. Operative treatment, he observes, is rarely indicated, and even in the

placed upon the need of reduction in these fractures. In January, 1929, Davis<sup>14</sup> reported 11 cases treated by obtaining the limit of hyperextension and maintaining it. With the patient prone the legs are lifted up by suspension until the pelvis clears the table by several inches. Some traction is exerted in the footward direction. A downward thrust is made upon the gibbus if necessary. A plaster shell is then applied from the head to the knees for six to ten weeks and is followed by a Taylor spine brace.

The results obtained by Dunlop and Parker<sup>15</sup> are so striking that their method will be described verbatim.

The reduction of these fractures is accomplished by forcible hyperextension of the back, while strong traction and counter traction

were applied to the body. The traction is obtained by two men pulling upward on sheets which are passed diagonally across

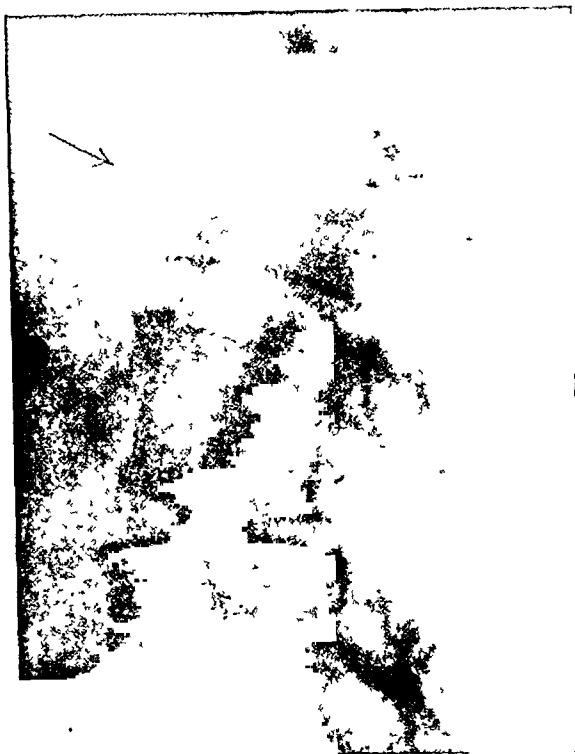


FIG. 3., February 25, 1929, nearly four months after injury. Showing poorer position than in Fig. 2.

the chest and under the arm of the opposite side; the counter traction is furnished by two men pulling downward on the ankles. The patient is placed under an anesthetic in the supine position, and a sheet folded to a width of 6 in. is passed beneath the injured segments. The operator and his assistant then toss the patient straight up and catch his weight on the taut sheet while the strong traction is applied to the body. Care is exercised to keep the back in a position of hyperextension. A body cast is then applied with the patient lying on a Goldthwait frame. The procedure may be repeated several times if it seems necessary.

Dunlop and Parker show most convincing x-ray studies before and after this treatment. Measurements of the films show the bodies to be actually widened and that this increase in width persists as long as sixteen months after the injuries with the patient back at work.

In the discussion of Dunlop and Parker's paper Dr. Eikenberry stated that he had

seen over 100 of these cases and in not a single case in which a fusion operation was done was the man able to go back to hard work. "The only patients who were able to go back to hard work were those who were treated conservatively." The operative method, however, has its advocates. Speed<sup>16</sup> recommends operation in compression fractures of the lower lumbar vertebrae or "where angulation is increasing."

In 1918 Brackett, Nuxter, and Wilson (quoted by Thomas) reported 27 cases of uncomplicated spinal fractures. Twenty-two of these cases were treated conservatively by recumbency and support and of these 18, or 82 per cent, showed a persistent partial disability. In 9 cases of patients, however who were operated upon, there was complete recovery in every case. Sever (quoted by Thomas) in 1917 reported 27 cases of compression fractures all totally disabled from further heavy duty and Cleary (quoted by Thomas) in 1924 reported 52 cases of compression fracture with an average disability of the unoperated cases of 40 to 50 per cent. In 1928 Thomas<sup>17</sup> reported the end-results of 100 cases of spine injury in a mining community. There were 46 compression fractures in this series with no deaths. Twelve cases were not followed up. In the remaining 34 cases, 15, or 45 per cent, showed no disability; 3, or 9 per cent, showed 5 to 25 per cent disability; 7, or 20 per cent, showed 25 to 50 per cent disability; 3, or 9 per cent, showed 50 to 75 per cent disability, and 6, or 17 per cent, showed total permanent disability. With partial to total disability in more than half of the cases, Thomas has now adopted the policy of doing a fusion operation, preferably of the Hibbs type, in all compression fractures without cord lesions. He will report his results later.

The present cases are drawn from a series of 21 spinal injuries. Of these 2 were complicated by paralysis, 3 involved the cervical spine, 3 were compression fractures sustained too recently to note

the result, 1 was a compression fracture not seen until one year after the injury, 3 were compression fractures which were

worn from three to nine months and then was gradually removed. In two of the women patients, G. J., and J. O. E.,

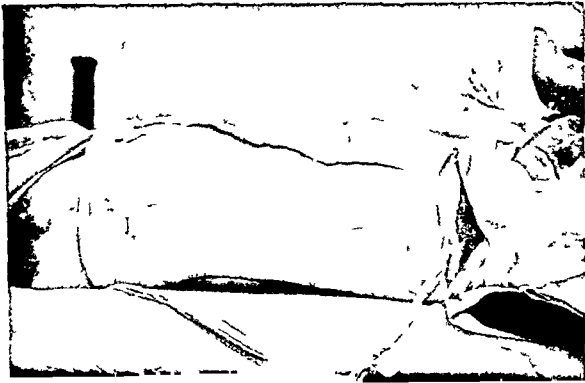


FIG. 4. Plaster body cast applied with patient's face downward and with back in lordosis. Note large window cut out to facilitate breathing, and also "scratcher" bandage passed underneath cast.

not able to be followed, and 9, the series studied, were uncomplicated compression fractures of the dorsal and lumbar vertebrae which were able to be followed up. Table 1 gives the details of these cases.

Perhaps the most important single factor in the treatment of these cases is proper care of the patient's mental condition. The patient's condition should be described to him truthfully and accurately. He should be told that he has not a broken back in the customary sense of the word, but that he has a lesser injury of one of his vertebrae. He can be told that the prognosis is excellent but that he must follow instructions explicitly.

The usual treatment was to suspend these patients prone in the hammock of an Abbott frame placing the back in hyperextension and to apply a plaster body cast in this position. In some cases, a strong downward thrust was made over the injured vertebra before the cast was applied. After they were placed in bed a large ventral window was cut out of the cast to facilitate respiration and to make greater comfort after eating (Fig. 4). The patients were kept recumbent for at least six weeks and then gradually were permitted to walk about with a well fitted Taylor spine brace. The spine brace was



FIG. 5. Turnbuckle suspension for compression fracture of spine. Note that spreader bars are attached by adjustable tapes to ribbed corset back. No ribs must be immediately over spinous processes. By means of adjustable tapes and turnbuckle required degree of lordosis is obtained and maintained.

a body cast was not used but the entire treatment was carried out on a Bradford frame in lordosis. The lordosis was brought about by placing under the injury smoothly folded flannel blankets of the proper shape and thickness. More recently the writer has employed upward traction to a Balkan frame to secure hyperextension in the cases of rather fragile elderly women. After the patient is placed on an ordinary Bradford frame an ordinary woman's corset is placed under the site of the injury. The sides of the corset are then trimmed off and attached by numerous adjustable tapes to a 12 to 14 in. wooden spreader bar. The two spreader bars are in turn attached to an overhanging spreader which is suspended from the Balkan frame by a turnbuckle attachment. The turnbuckle is tightened up a little each day during the first week until

TABLE I

Patient	Sex	Age	Date of Injury	Cause of Injury	Vertebral brae Affected	Complications	Treatment	Days in Recum- bency	Days in Spine Brace	Interval from Injury to Follow-up	Condition on Follow-up	Result
A. F. . . . .	M.	49	7/3/26	Struck by train	4 L	9 minor fractures of spine, compound fracture l. leg, 15 rib fractures	Amputation l. leg, rest in bed, Taylor spine brace.	91	49	3 years, 7 mos.	No pain in back. Not wearing brace. Not doing same work as before (amputation).	G.
G. J. . . . .	F.	42	3/18/27	Fall from window.	2 L	Bilateral Colles' fractures.	Rest in lordosis, on Bradford frame. Taylor spine brace.	57	180	2 years, 10 mos.	No pain. Doing same work as before. Wears corset.	E.
D. M. . . . .	F.	44	5/21/27	Fall from horse.	7 D	None.	Body cast. Taylor spine brace.	39	180	2 years, 8 mos.	No pain. No brace worn. Walks 12-15 miles daily or several sets of tennis.	E.
F. H. . . . .	M.	38	5/10/27	Fall from scaffold.	1 L	Fracture middle mal- leolus left tibia.	Bradford frame, body cast, Taylor spine brace.	63	180	2 years, 8 mos.	No pain except a twinge with sudden twist. Same work as before (bricklayer). No brace but wears belt.	G.
A. P. . . . .	M.	26	6/3/27	Fall astride ladder.	2 L	Rupture of urethra (requiring 2 operations).	Rest in bed, Taylor spine brace.	70	120	2 years, 7 mos.	No pain in back. Same work as before (painter). No brace. "Never felt better in my life."	E.
E. H. M.	M.	46	1/16/28	Fall down icy steps.	1 L	None.	Body cast in lordosis. Taylor spine brace.	35	35	2 years.	No pain in back. Same work as before. No brace. "I am 100 per cent."	E.
C. L. . . . .	M.	42	4/24/28	Fall from scaffold.	12 D	Colles' fracture.	Body cast Taylor spine brace.	45	270	1 year, 9 mos.	A "trifle" of pain in the back just above hips when sitting (not at site of fracture). Same work as before. No brace. Spent considerable time in bed for over 1 year.	G.
J. E. . . . .	M.	46	10/31/28	Fall from ladder.	1 L	None.	Body cast Taylor spine brace.	49	77	1 year, 3 mos.	Slight pain in back in morning and night. Not doing same work as before injury. No brace or support. Walks as well as before. "Not able to sleep at night."	F.
J. O. E. . . . .	F.	61	12/20/28	Fall from stepladder	12 D	None.	Bradford frame with supporting sling. Taylor spine brace.	49	135	1 year, 5 mos.	No pain in back. Doing splendidly. Slight dull ache when tired. No brace. Wears corset.	E.
Average . . . . .		43.7 years						55 days	136 days	27.5 mos.		

the proper hyperextension of the spine is secured (Fig. 5).

After the patient is ambulatory it is important to adjust the Taylor spine brace with brace wrenches so that it accurately conforms to the lordosis curve of the back. A properly made corset, fitted by an expert, will maintain lordosis in a slight woman. It should be supplied with an inner belt.

Analysis of the table shows that the average age of the 9 cases was 43.7 years; the average period of recumbency was fifty-four days; the average time of wearing of the back brace was 136 days; the average time of follow-up report was 27.5 months. The first lumbar vertebrae was involved three times; the second lumbar and twelfth dorsal each twice; and the fourth lumbar and seventh dorsal each one. In 8 cases

there is no definite report of pain in the back at the site of the fracture. In the ninth case "no pain except a twinge with a sudden twist" was reported. Seven patients are doing the same work as before the accident. Of the 2 who are not doing the same work, one is prevented from doing so by an amputation of one leg. The seventh patient (C.L.) had apparently the most protracted convalescence saying that for a year he spent considerable time in bed.

In conclusion, the results in the 9 cases treated by conservative measures and followed in an average of 27.5 months, may be summed up as follows:

Excellent . . . . .	5 (55.5 per cent)	} 88.8 per cent
Good . . . . .	3 (33.3 per cent)	
Fair . . . . .	1 (11.1 per cent)	
Poor . . . . .	0	

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# DEFORMITIES AND OBSTRUCTION OF THE DUODENUM\*

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THE usual causes of deformities and obstruction of the duodenum are ulcer, gall bladder and periduodenal bands and membranes, diverticula of the duodenum or first loop of jejunum and compression of the duodenum by mesenteric pedicle of the superior mesenteric or median colic arteries.

There is a well defined pathological anatomy and disturbed function produced by these conditions and in the cases of obstruction a clear-cut clinical picture, which x-ray studies may confirm with an accuracy of 90 to 95 per cent; even in the cases of ulcer, adhesions from the gall bladder and diverticula, though the clinical picture is not infrequently confusing, persistent x-ray studies may finally clear up the diagnosis in almost every case.

## A. ULCER OF THE DUODENUM

The typical history of pain or discomfort in the epigastrium or right hypochondrium, when the stomach is empty or emptying its acid contents, with periods of relief and exacerbation of symptoms persisting for months or years and frequently in young healthy looking individuals, is familiar to all. The x-ray studies portray varying shadows in the course of development of a callous ulcer from duodenal spasm to well defined filling defect when the ulcer is definitely formed. A progressive obstruction in the second or third portion of the duodenum may hasten ulcer formation and ulcers may form below the duodenal cap.

CASE 1. Mr. R. H., aged thirty-five, with typical symptoms of duodenal ulcer who in spite of irregular Sippy and antacid diet, belladonna and alkalies had profuse vomiting of blood, improved and hemorrhage ceased after medical treatment. Filling defect persisted (Fig. 1), with gastroenteroptosis and

dilated duodenum. Finney pyloroplasty with resection of ulcer; pathological report of malignant ulcer (discredited). Symptom-free for eighteen months, usual confusing shadow-graft following pyloroplasty (Fig. 2). Sudden recurrence of symptoms and acute perforation; perforation cauterized and closed, gastroenterostomy to relieve tension in duodenum. Symptom-free for fourteen months; recurrence of pain in epigastrium and tenderness, ulcer at gastrojejunal anastomosis (Fig. 13). Free of symptoms for year after short treatment with belladonna, alkalies and antacid diet. Impression: a duodenojejunal anastomosis followed by pyloroplasty and resection of ulcer would have forestalled recurrence of ulcers.

CASE II. Mrs. M., aged sixty-two; pain in epigastrium, occasional vomiting. Two x-ray series with barium enemata and visualization of gall bladder, showed only gastroenteroptosis and moderately dilated duodenum. Improvement of short duration on belladonna, alkalies and antacid diet, attacks of pain in epigastrium recurred from time to time over a period of four months' observation; finally passed blood by bowel and vomited blood. X-ray study showed dilated and deformed duodenum, (Fig. 4). At operation dilated duodenum, ulcer in second portion of duodenum, relieved of pain by gastroenterostomy for eight months to date. Impression: Same relief of symptoms and likely more enduring comfort by duodenojejunostomy.

CASE III. Mr. M., aged forty-nine, vomited for twenty-four hours voluminously, small bowel movements after repeated enemata, arrived at hospital at night under diagnosis of partial intestinal obstruction. Moderately distended abdomen, scar of former appendectomy, slight tenderness over right hypochondrium, temperature 101°F., pulse 82. Blood pressure 130/70, white blood corpuscles 19,800, few white and red blood cells in urine. Cystoscopy negative, x-rays of gastrointestinal tract. Diagnosis: duodenal ulcer perforating (Fig. 5). At operation gall bladder bound

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closely to duodenum, containing mucopus and stones. Liberation and removal of gall bladder. Complete relief.

irritation as there is considerable tendency to spasm of the cap and at times, the peristalsis of the stomach is exceptionally vigorous.



FIG. 1. Case 1. Persistent ulcer after hemorrhage; ulcer, clearly visible and palpable at operation, resected. Finney pyloroplasty.

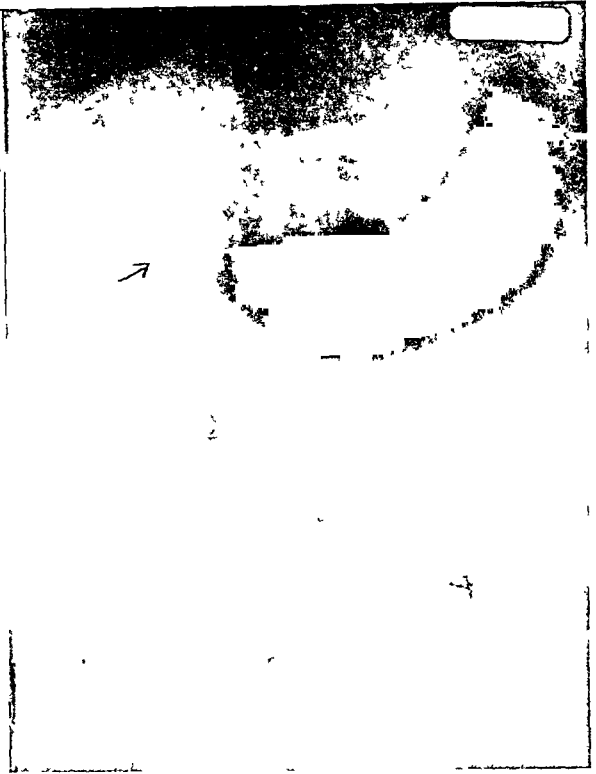


FIG. 2. Case 1. After Finney pyloroplasty and resection of ulcer, dilatation of duodenum, recurrence of ulcer and perforation. Cauterization and closure of ulcer and gastroenterostomy. Recurrence of ulcer from stasis and tension likely prevented by duodeno-jejunostomy and resection of ulcer.

CASE IV. Mr. A. B., aged thirty-five to forty-five during examinations. At one time symptoms of duodenal ulcer, relieved by belladonna, alkalies and antacid diet; at another time of gall bladder; at another colitis with gas, soft stools or diarrhea with some mucus, always better after thorough purging with salines and on diet with minimum red meats and roughage. Local roentgenologist diagnosed duodenal spasm and spastic colitis; Dr. Fred Baetjer (Baltimore) appendicitis with duodenal spasm; Dr. Pancoast (Philadelphia) adhesions from cholecystitis or duodenal ulcer, poorly drained appendix. The following are the conclusions of Lewis Gregory Cole (New York) after a most elaborate and protracted x-ray study:

From a study of these roentgenograms, I believe one is justified in making a negative diagnosis of cancer and ulcer of the stomach and a negative diagnosis of the cap. There is no pyloric stenosis, no functional gastric retention; in fact, the stomach empties more rapidly than usual. There is apparently some

There is a diverticulum of the first part of the descending duodenum. (This diverticulum was never found before in the several x-ray studies. Was it acquired or was it always present during these former studies?) This lies to the left of the duodenum and apparently anterior to, and in close relation to the junction of the common bile duct and pancreatic duct.

I find no evidence of calcified gallstones. The gall bladder did not fill with the dye, although this was given orally on two successive days. In our experience this is quite positive evidence that the gall bladder is diseased.

(What relation does the diverticulum bear to failure of the gall bladder to fill, located as it is in close relation to the junction of the common bile duct and pancreatic duct; what would be the difficulties of satisfactory removal at this location and if removed the chances of further obstructing the ducts and finally what are the dangers of such diverticula



beyond a causative agent in the patient's discomfort?)

"I believe one is justified in making a nega-



FIG. 3. Case 1. After closure of recurrent and perforated duodenal ulcer and gastroenterostomy. Marginal ulcer  $\frac{1}{2}$  in. median from arrow point, rapidly emptying stomach and colitis. Gastroenterostomy to be closed, followed by duodeno-jejunosomy.

tive diagnosis of a diverticulosis of the lower descending colon and the sigmoid colon. There is no evidence of diverticulitis. The appendix is patent, almost six inches long and apparently contains several small fecoliths. I would consider this a pathological condition of the appendix but I do not believe it is by any means a surgical condition. There is apparently, a congenital veil or band of adhesions in the right hypochondrium which involves but does not obstruct the hepatic flexure of the colon.

(This patient with unfilling gall bladder, duodenal diverticulum, pathological appendix and hepatic adhesions remains unoperated on, relieved of the fear of perforating ulcer and ruptured appendix. What surgeon could resist operation on this case?)

#### B. ADHESIONS FROM GALL BLADDER

Those cases are confused with duodenal

ulcer as cited under Case III (Fig. 5), where a gall-bladder visualization was not done either on account of the acuteness of the case or confidence in the diagnosis, when there was an apparent conformity between clinical data and apparent x-ray findings. An accurate diagnosis can usually be made when the x-ray studies are persistent as in Case IV.

#### C. PERIDUODENAL BANDS AND MEMBRANES

The supramesocolic bands or membranes are confusing and probably can not be diagnosed clinically or by x-ray study with any degree of accuracy and are found at operation under the diagnosis of cholecystitis and duodenal ulcer with adhesions. The inframesocolic bands and adhesions may be projected, as from the symptoms of persistent duodenal obstruction, without relief from position or posture and x-ray findings of a dilated and obstructed duodenum.

CASE V. Mr. G., aged forty-eight weight 106 lb., loss of 40 lb. in weight, pain in epigastrium, frequent attacks of nausea and voluminous vomiting, pale and weak. X-ray study showed dilated duodenum, dilated stomach with eleven hours gastric retention (Fig. 6). At operation bands of adhesions at terminal duodenum and rolling and narrowing of duodenum, dilatation of proximal duodenum. Duodenum liberated and anastomosis made between first loop of jejunum and inframesocolic duodenum. The patient never vomited again, was on a full diet in the course of three weeks and according to his own statement remains perfectly well with a weight of 160 lb., eating what and when he wants. He has remained well for six years. A defect in cap shown in x-ray and diagnosed ulcer was not found at operation as a visible and palpable ulcer.

CASE VI. Mr. J., aged thirty-eight. This patient, lying on a stretcher, pale, thin, weighing 98 lb., was shown before the local medical society with Mr. G., Case V, standing beside him. The contrast was startling. This case had lost about 50 lb., had severe pain shortly after taking food, frequent attacks of nausea and voluminous vomiting. Had become

a morphine addict. He showed a four plus Wassermann reaction. X-ray showed gastroenteroptosis, markedly dilated duodenum in

was done. After operation there was frequent vomiting of large quantities of bile stained fluid, so-called vicious circle. The vomiting



FIG. 4. Case II. Dilated and deformed duodenum, ulcer in second portion, upper bulging near cap an artefact, after violent hemorrhage. Two former x-ray studies negative. Relieved by gastroenterostomy. Stasis and tension in duodenum would have been better provided for by duodenojejunosomy.

all pictures, gastric retention of twelve hours or more (Fig. 7). He had been receiving anti-luetic treatment. At operation there were numerous adhesive bands around the terminal duodenum, this portion was thickened and hard and a definite constriction band was felt in the walls of the intestine, the proximal duodenum markedly dilated. An inframesocolic duodenojejunosomy was done. After operation no more vomiting, there was a gain of 30 lb. in the first month, in spite of an ever positive Wassermann reaction and a continuation of the morphine habit. In course of time the patient developed paresis and finally died with terminal pneumonia but never vomited again.

CASE VII. Miss C. M., aged thirty-two thin, pale, frequent attacks of nausea and voluminous vomiting. X-rays showed moderately dilated duodenum and stomach, gastric retention for eleven hours. A gastroenterostomy



FIG. 5. Case III. Artefact produced by gall bladder adhesions. Relieved by liberation of gall bladder from duodenum and cholecystectomy.

was relieved by elevating the foot of the bed. Vomiting frequently occurred during six months and there was no improvement. Repeated x-rays showed markedly dilated duodenum and stomach and prolonged gastric retention (Fig. 8). At the second operation the terminal duodenum was found to be surrounded by adhesions and narrowed and the terminal loop of jejunum used for gastroenterostomy carried to the left, made a sharp angle at the duodenojejunal junction. A duodenojejunosomy was done. There was no more vomiting, a rapid gain in weight and marked relief but multiple neurotic complaints, such as irregularity of menstruation, pain in hips, etc. X-rays after duodenojejunosomy showed stomach emptying in four hours and rapid passage into cecum (Fig. 9).

CASE VIII. Mr. H., aged thirty-four, with pain, frequent nausea and vomiting, loss of appetite and weight, relieved by liberation and unrolling of terminal duodenum from bed of constricting bands, without duodenojeunos-

tomy (Fig. 10). There is a possibility of recurrence of adhesions, though patient remains well for nearly two years.



FIG. 6. Case v. Dilatation and deformity of fixed obstruction of duodenum by adhesions and rolling of terminal duodenum. Nitch in cap diagnosed ulcer, not visible and palpable at operation. Completely relieved by duodenojejunostomy.

**CASE IX.** Mrs. McD., aged forty-two. Thin, pale, frequent attacks of voluminous vomiting. History of possible tuberculous peritonitis when a child; formerly had cholecystectomy. X-rays showed dilated stomach and duodenum with nine hours' gastric retention, gastroenteroptosis. At operation there were multiple bands at terminal duodenum, marked angulation at duodenojejunal angle, and membrane holding terminal duodenum and proximal jejunum together. At operation, that duodenum and stomach relieved without failure of obstruction, the duodenojejunal angle was liberated from bands and membranes and also from the ligament of Trietz and the anastomosis made between gastric antrum and the duodenojejunal junction. The patient improved, gained weight but soon had an occasional return of attacks of vomiting and some diarrhea. The stomach and duodenum now empty about as fast as the barium meal can be given

(Fig. 11). The gastric contents rapidly fills the small intestine and by rapid overloading, vomiting recurs. Impression: At the opera-

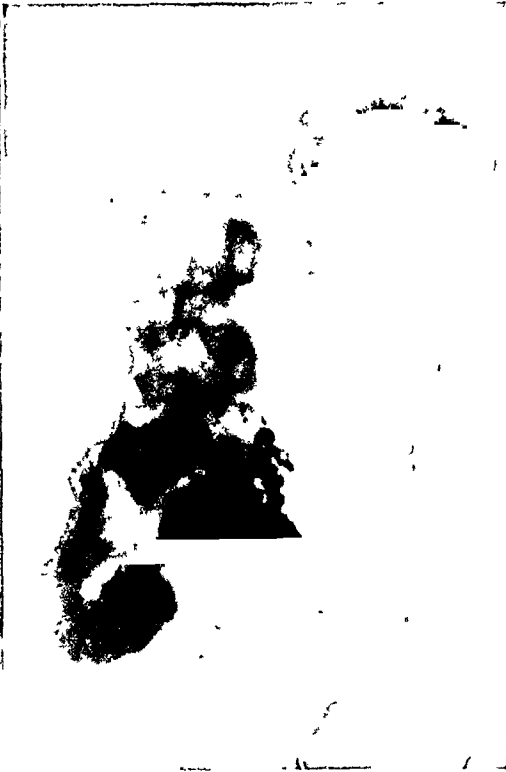


FIG. 7 Case vi. Dilatation and fixed obstruction of terminal duodenum by extrinsic adhesions and intrinsic stricture (4+ Wassermann reaction) completely relieved by duodenojejunostomy.

tion a duodenojejunostomy would have sufficed. The question is now before us of taking down the gastroenterostomy and making a duodenojejunostomy.

#### D. DIVERTICULA OF THE DUODENUM AND JEJUNUM

Case iv, under the heading of duodenal ulcer, illustrates the confusion in diagnosis in some of these cases.

**CASE X.** Mr. R. A. D., aged sixty-eight, who forty years ago had several attacks of pain, nausea, occasional vomiting, gas and soft stools, which was empirically diagnosed as bilious colic and for which he was given calomel and salines and relieved. During such an attack eighteen years ago, under the diagnosis of appendicitis an exploratory operation was advised and halted by his surgeon and friend Dr. John Gibbon, who saw him in consultation with New York surgeons

and advised a wait on account of atypical symptoms and uncertainty of diagnosis. To this day he occasionally has a little nausea

separate blood supply from that of intestine with vessels branching separately from both layers of mesentery.



FIG. 8. Case VII. Markedly dilated duodenum after gastroenterostomy, so called vicious circle, followed by persistent duodenal obstruction. Completely relieved by duodenojejunostomy at second operation.



FIG. 9. Case VII. Rapidly emptying duodenum after duodenojejunostomy.

and soft stools, quickly relieved by an oil purge. His physical findings, except for slight tenderness over the epigastrium during an attack, are negative. X-ray studies show a diverticulum involving the second portion of the duodenum, which is smooth in outline, freely movable, not tender to palpation and the barium meal is seen to enter and leave the diverticulum during fluoroscopic examination (Fig. 12). The six-hour picture shows a small residue in the diverticulum after the stomach and duodenum have emptied (cf. Figs. 13 and 14, Cases XI and XII).

**CASE XIII.** Mrs. McQ., aged fifty-two, 65 lb. loss of weight, slight gastroenteroptosis, pain and distress felt in epigastrium, nausea, attacks of vomiting and soft stools. Moderately dilated duodenum between attacks. Diverticula not found in roentgenograms, visualization of gall bladder negative. Operated on for prolapsus uteri with exploration of upper abdomen. Two diverticula found just distal to duodenojejunal junction, one size of lemon with all coats of the intestine and abundant

This diverticulum resembled largest Meckel's diverticulum I have seen, with a blood supply suggesting a congenital origin. The second diverticulum was small, thin walled and no such blood supply (Cases XI and XII, Figs. 13 and 14). The large diverticulum by location, adhesion and weight, when filled produced an intermittent and partial obstruction at the duodenojejunal angle and produced the attacks of nausea and vomiting and partial obstruction of the duodenum.

#### E. COMPRESSION OF DUODENUM BY MESENTERIC PEDICLE OF SUPERIOR MESENTERIC AND MEDIAN COLIC ARTERIES (DUODENAL ARTERIOMESENTERIC ILEUS)

**CASE XIV.** Mrs. B., aged forty-two, attacks of pain in epigastrium as well as pain in right lower abdomen, profuse menstruation, vomiting, elevation of temperature and leucocytosis, negative urine. Poor result with enemata. Brought to hospital as acute abdominal case and diagnosis of ovarian cyst. Was formerly

operated on for tuberculous spine with bone graft and appendectomy. Abdomen flat, scar of former appendectomy, tenderness and

and taking food. Impression: Duodenal arteriomesenteric ileus (acute dilatation of stomach). Compare with Case VII (Figs. 8 and

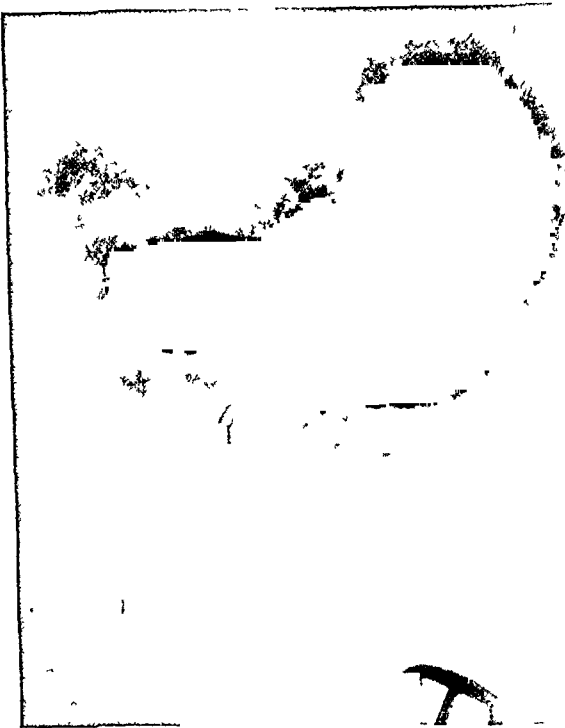


FIG. 10. Case VIII. Slightly dilated duodenum. Duodenal obstruction relieved by ligation of adhesions and rolling of terminal duodenum. Operation of choice duodenojejunostomy to prevent recurrence of adhesions.



FIG. 11. Case IX. Gastroenterostomy between detached duodenojejunal angle and stomach. Extremely rapidly emptying stomach, vomiting and colitis. Projected operation: Closure of gastroenterostomy and duodenojejunostomy.

definite resistance over cecal region. Soft mass over right adnexa, small mass over left adnexa. Diagnosis: Ovarian cysts right and left, partial intestinal obstruction. At operation ovarian cyst size of lemon on left side. Cecum down in right side of pelvis, filled with soft doughy fecal matter, ascending colon adherent to peritoneum, at site of former appendectomy. Colon liberated from abdominal wall, enucleation of left ovarian cyst. Patient vomited after operation large quantities of bile-stained fluid, in spite of good results following enemata on the second and third days, and continued to vomit in spite of the fact that the abdomen remained soft. After a large enema and turning the patient over on her abdomen with foot of bed elevated, there was a cessation of vomiting and a sudden movement of bowels filling the bed. The patient was sustained on salt solution and glucose given in frequent and large quantities intravenously during her vomiting. By the fifth day she was entirely comfortable

9) and so-called vicious circle following gastroenterostomy.

CASE XV. Mr. D., aged thirty-one. Attacks of pain in epigastrium, at times very violent, followed by frequent and voluminous vomiting of bile-stained fluid. Pale, loss of weight and weakness. Attacks, at first, spaced by months' time, but became more frequent. This case was followed over a long period with repeated x-ray studies between attacks, which studies showed a gastroenteroptosis with moderate dilatation of duodenum. Finally examined during an attack; posture failed to relieve him. Barium meals given him were vomited. By persistent giving of barium while under the fluoroscope, the duodenum was seen to dilate widely, peristalsis immediately became very active, a small amount of barium would pass the terminal duodenum, quickly followed by violent antiperistalsis and rapid back-flow into the stomach, contraction of the stomach

and vomiting. After many attempts a film was obtained (Fig. 15). At operation, the duodenum was dilated, there was a rolling

finding and employing definite fibers of crystallization as described under the nephrocolic ligament of Longyear. This operation was



FIG. 12. Case x. (Cf. Figs. 13 and 14). Large diverticulum of second portion of duodenum. Occasional pain and nausea, followed by diarrhea. Not operated on.



FIG. 13. Case xi. Diverticula in second portion of duodenum and in terminal duodenum. No obstruction, minor symptoms, not operated on. Similar case showed duodenal obstruction. Relieved by liberation of adhesions and resection of diverticula.

of the terminal duodenum on the peritoneum with a few light adhesions, the mesenteric pedicle of the superior mesenteric artery pressed tightly down on the terminal duodenum and when lifted with the finger under it, could be felt to pull down on the finger with considerable weight. An inframesocolic duodeno-jejunosomy was done. The patient has experienced a complete relief of pain and vomiting immediately from time of operation to date, with absolute feeling of well-being and an appreciable gain in weight and color. Although but three months following operation his gain is still progressive.

CASE XVI. Miss McL., aged twenty-eight. Pain over right back, right lower abdomen, attacks of violent vomiting. The right kidney felt in the region of the cecum. X-ray studies showed the cecum in the location of the pelvis. Diagnosis: Nephrocoloptosis. The kidney was fixed after the method described by Longyear,

done ten years ago, the kidney remains in position, the urine is negative and the cecum occupies about its usual position. There have been no more attacks of vomiting, the patient is in good health and comfort except for slight pain in the right lumbar region. Impression: Duodenal stasis from dragging on duodenum and compression by mesenteric pedicle of median colic artery.

CASE XVII. Miss T., aged twenty-three. Very thin, pale girl, complaining of marked constipation and great difficulty in emptying bowels, weakness; even talking is great effort and voice is almost lost. Gastroenteroptotic type, enormously dilated cecum and ascending colon entirely prolapsed into pelvis. Attacks of pain in epigastrium and continuous voluminous vomiting. At operation an enormously dilated cecum and ascending colon, six inches across transverse diameter with thickened

walls and filled with doughy fecal matter was lifted out of pelvis and brought entirely out of incision. There was no parietal peritoneal

be noted that pain, attacks of vomiting, loss of weight and color were the main characteristics in 11, namely Cases III, V,

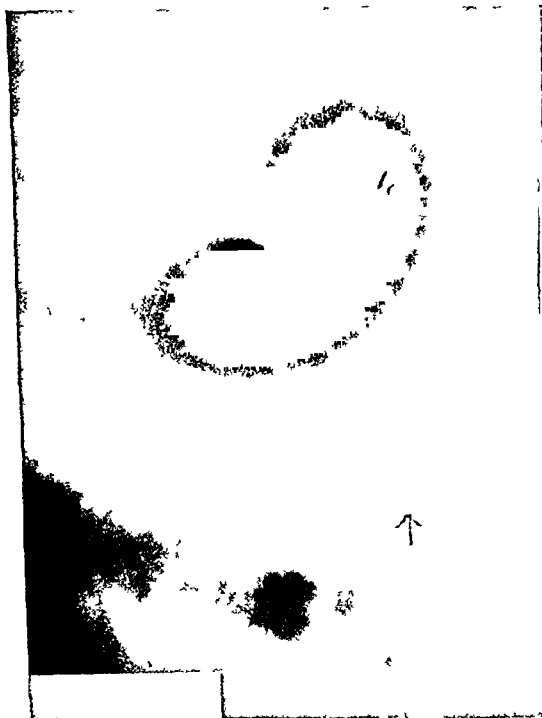


FIG. 14. Case XII. Diverticulum of upper jejunum, rarely shown in x-ray studies. Diverticula in case occurred in upper jejunum as well as at duodeno-jejunal junction. (Cf. Fig. 13.)



FIG. 15. Case XV. Marked recurrent dilatation of first and second portions of duodenum becoming more fixed. Compression by arterial pedicle of superior mesenteric artery and adhesions. Relieved by duodenojejunosomy.

attachment until the hepatic flexure was reached and the attachment here was a long loose membrane. The mesocolon was easily tied and severed and the entire cecum and ascending colon resected at the hepatic flexure, where a lateral anastomosis was done between the ileum and transverse colon, just distal to the hepatic flexure. There have been no more attacks of pain in the epigastrium and vomiting, but a gain in weight, strength and color and a return of a strong voice. The girl has been working for two months following her operation and has applied to the hospital for nurse's training. X-ray studies following operation show a ready passage of barium through stomach, duodenum and transverse colon with delay in descending colon and sigmoid. She still requires petrolagar for abundant bowel movements. Impression: Duodenal stasis from compression by mesenteric pedicle of median colic artery.

#### DUODENAL OBSTRUCTION

In the seventeen cited cases there will

VI, VII, VIII, IX, XIII, XIV, XV, XVI, XVII, and to a milder degree in Cases I and II. Cases I and II were both of the gastroenteroptotic type, both vomited blood. X-ray studies showed the ulcer and a dilated duodenum. Case I had a recurrence of ulcer and perforation after closure of second ulcer and gastroenterostomy; Case II showed ulcer below the duodenal cap and was relieved by gastroenterostomy. It was suggested that duodenojejunosomy followed by resection of the ulcer should have been the operation of choice in both cases, to drain more directly the dilated duodenum and would likely have prevented the recurrence of ulcer and perforation in Case I and have secured more permanent results in Case II. Case IX was overdone and the effect produced was that of combined duodenojejunosomy and gastroenterostomy. Case VII was a failure after gastroentero-

stomy and was relieved after additional duodenojejunostomy. Both cases should have received a duodenojejunostomy only, at the first operation. Case III was frankly cholecystitis and cholelithiasis, but even in this case the gall bladder was intimately adhered to the duodenum, producing the artefact of an ulcer. In only 1 of the 5 cases of diverticula, Cases IV, X, XI, XII, XIII, were pain and vomiting prominent symptoms and in Case XIII the diverticulum near the duodenojejunal angle so lay and adhered as to obstruct the duodenum; symptoms in Case IV were likely due to the gall bladder since it failed to visualize after the dye and two x-ray studies. Cases VII and XIV were temporarily relieved of pain and voluminous vomiting by posture; Case VII was permanently relieved at the second operation by duodenojejunostomy; Case VII developed the so-called vicious circle following gastroenterostomy and was later relieved at second operation by duodenojejunostomy. Case XIV developed the so-called acute dilatation of the stomach following the operation on the lower abdomen. Duodenal obstruction, vicious circle and acute dilatation of the stomach are frequently most likely one and the same thing. In Cases XVI and XVII the drag and pull and hence compression of the duodenum by the mesenteric pedicle of the median colic artery were relieved by nephrocolopexy (Longyear) and resection of megalocecum and colon respectively.

By reconstruction of clinical findings and x-ray studies in these cases of duodenal obstruction, the following symptoms are to be noted as most prominent and characteristic:

1. Vomiting of bile-stained fluid often in enormous quantities.
2. Pain located over the whole epigastrium or right hypochondrium, sensation of weight and discomfort or the negro's "misery" in the epigastrium, between attacks and violent pain during attacks.
3. Emaciation and pallor; the gastroenteroptotic type of patient.
4. Relief by posture or abdominal sup-

ports except when the obstruction has become fixed, as in Case VII, so-called vicious circle and in Case XIV so-called acute dilatation of the stomach or by taking away the weight on the mesenteric pedicle of the median colic and superior mesenteric arteries by nephrocolopexy or resection of the colon as in Cases XVI and XVII.

5. The duodenogastric type, severe and with acute duodenal obstruction, in which the organic breakdown pushed to a maximum and death may ensue, Cases V-VII.

The colonic type with right-sided constipation and cecocolonic stercoral stasis dominates the scene with duodenal compression as an accessory, Cases XIV, XVI, and XVII.

6. Complications, particularly of duodenal ulcer, recurrent duodenal ulcer and duodenal ulcer below the cap, Cases I and II.

7. X-ray findings of dilated duodenum, gastroenteroptosis, coloptosis studied during an attack of pain and vomiting, as Case XV; marked dilatation of the duodenum stopping suddenly at the midline; antiperistalsis and churning movements in the distended duodenum, reflux into the stomach, antiperistalsis in stomach, contraction and vomiting or antiperistalsis passing up duodenum and stomach at the same time with projectile vomiting.

There is a sharp line of demarkation between the right part of the third portion of the duodenum filled with the opaque meal and the left part which is empty, Case XV (Fig. 15).

#### TREATMENT

The procedures employed in 13 of the 17 cases cited here were:

1. Posture in so-called acute dilatation of the stomach following operation on the lower abdomen, Case XIV and in so-called vicious circle following gastroenterostomy in Case VII with temporary relief in both cases.

2. Simple liberation of terminal duodenum, Case VIII.



3. Gastroenterostomy, Case VII and anastomosis of duodenojejunal angle, equal to gastroenterostomy plus duodenojejunos-tomy, Case IX with failure in both cases. Duodenojejunos-tomy alone would likely have been the proper original procedure, likewise gastroenterostomy as final operation in Cases I and II when duodeno-jejunos-tomy would have been better surgical judgment, although both cases are relieved of symptoms.

4. Nephrocolopexy, Case XVI, relieved for ten years.

5. Cecocollectomy, Case XVII relieved for eighteen months.

6. Resection of diverticulum of jejunum and liberation of adhesions, Case XIII.

7. Duodenojejunos-tomy, Cases V, VI, VII and XV with relief of symptoms immediately

and permanently and with results equal to the relief of any case of acute high intestinal obstruction.

X-ray studies following duodenojejunos-tomy show the opening functioning perfectly, that the duodenum emptying is regular and that antiperistalsis has disappeared, Case VII (Figs. 8 and 9).

The operation of duodenojejunos-tomy is the operation of choice in the duodeno-gastric type of duodenal obstruction, in certain cases of duodenal ulcer with gastro-enteroptosis and dilated duodenum and in all of acute duodenal obstruction, regardless of cause of obstruction, where and when, on account of time, remote causes of obstruction cannot be determined.



# LYMPHANGIOMA OF THE MESENTERY

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**B**ENIGN tumors of the mesentery, judging from the infrequent case reports in the literature, are of comparatively rare occurrence. The first case of mesenteric tumor successfully treated by operative procedure was reported by Tillaux in 1880. Since then, cases have been reported in the literature from time to time, most of them being sarcomas, fibromas or lipomas. Lymphangioma or lymphoma is apparently of exceedingly uncommon occurrence. Harris and Herzog<sup>1</sup> have reviewed 57 cases of solid mesenteric tumor, only 1 of which was of lymphomatous nature. Begouin<sup>2</sup> collected 29 cases and Vance<sup>3</sup> 27 cases, none of which were classified as lymphangioma. In a review of a series of cases of mesenteric tumor, Bowers<sup>4</sup> stated that of the solid benign tumors of the mesentery, lipomas predominate, with fibromas being of rather infrequent occurrence. He did not mention tumors of lymphoblastic origin. Royster<sup>5</sup> has reported a case of blood tumor of the mesentery, which may have been a hemorrhagic lymphangioma. Bigelow and Forman<sup>6</sup> cite a case of lymphosarcoma of the mesentery. Ransohoff and Friedlander<sup>7</sup> state that mesenteric tumors are almost invariably of connective tissue origin, the vast majority being fibromas, fibromyxomas, lipomas or sarcomas. Nassen,<sup>8</sup> in his series of cases, reported 1 case of lymphangioma of the mesentery of the ileum in a man aged forty-one. Extirpation of the tumor was performed with complete recovery. Rawls<sup>9</sup> published the report of a case of lymphangioma of the mesentery of the ileum occurring in a boy aged thirteen. The tumor was excised with an excellent result. Westman,<sup>10</sup> in an admirable article on mesenteric lymphangioma, reported a case in which the tumor was found in the

mesosigmoid of a boy aged eleven. Removal of the growth was followed by uneventful recovery. Judd<sup>11</sup> removed a lymphangiolympoma from the mesentery of the jejunum in a woman aged twenty-eight with an excellent result.

## CASE REPORT

The patient, a man aged thirty-nine, by occupation a clerk, came under observation November 15, 1928, complaining of intermittent dull pain in the lower abdomen, of about six months' duration. The pain apparently seemed localized in the lower midabdomen, dull, nagging in character, never severe, never crampy, and did not radiate. The patient noticed the pain especially when he was bending over his desk. About two weeks previous to observation, he thought he had felt a lump in his lower abdomen while he was bathing. He had no other abdominal symptoms. General health was excellent, no digestive disturbance, no loss of weight. The family history was non-essential. Aside from a few childhood diseases, the past history was without incident.

The patient was a well-developed, well-nourished man weighing 164 lb. In the lower mid-abdomen there was an easily palpable, firm, rounded mass, about the size of a hen's egg. The mass was not tender, and was exceedingly mobile, being easily pushed over to both the right and left lower abdominal quadrants. There was no demonstrable regional adenopathy. Rectal examination was negative. The rest of the physical examination was essentially negative. The hemoglobin was 82 per cent, erythrocytes 5,100,000 and leucocytes 6400. The differential count was normal. The blood Wassermann test and urinalysis were negative. Roentgenograms of the chest showed no evidence of metastasis. A colon ray with barium enema was negative. A clinical diagnosis was made of abdominal tumor, origin indeterminate, and exploration advised.

The abdomen was opened by a mid-right rectus incision. On exploration the mass was found to be a rather smooth, solid tumor,

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situated in the mesentery of the ileum about 15 cm. from the ileocecal juncture. Fortunately it was far enough away from the bowel so

is a cause of the more cavernous spongy-like lymphangiomas. The theory has been advanced that this stasis might be caused

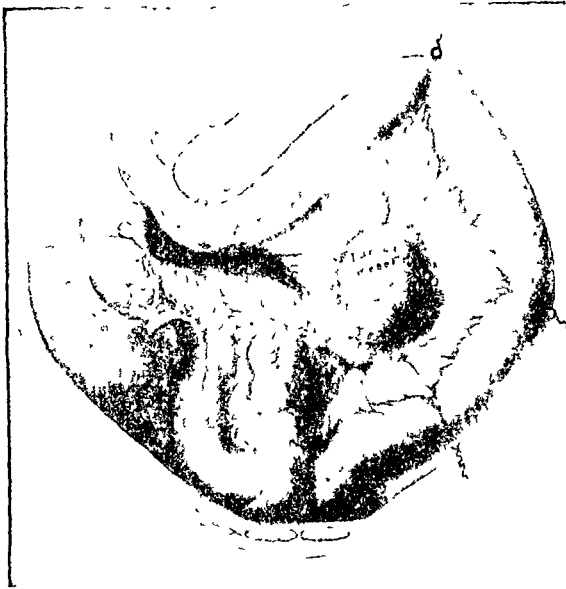


FIG. 1.

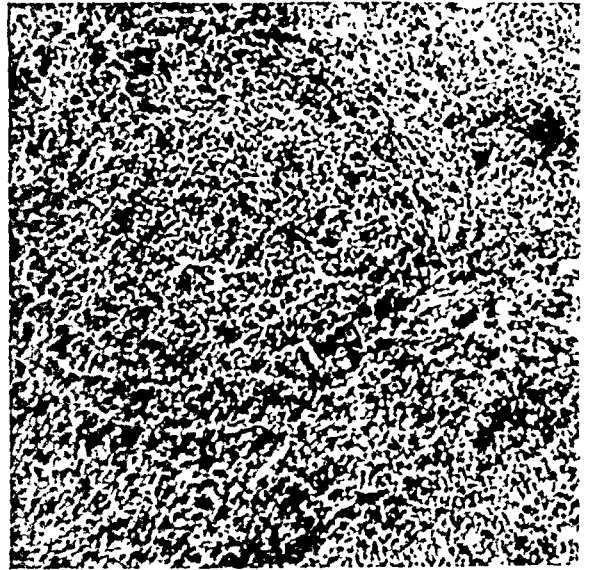


FIG. 2.

that it could be shelled out from between the mesenteric leaves without interfering with the blood supply to the gut. A few of the smaller mesenteric vessels required tying and the hole in the mesentery was closed with plain catgut. Further abdominal exploration was negative. As the color of the bowel adjacent to the mesenteric repair remained normal, the abdomen was closed. Convalescence was uneventful. The pathological report was: Tumor composed mostly of spongy lymphangiomatous tissue, with some areas of lymphoid tissue, the whole enclosed in a fibrous capsule. No evidence of malignancy. Diagnosis: Lymphangioma of the mesentery.

#### COMMENT

In regard to the structure of these lymphoblastic mesenteric growths it may be said that they are mainly composed of lymphangiomatous tissue in conjunction with typical lymph-glandular tissue. They are thus probably true lymphangio-lymphomas. The pathogenesis of these tumors is, of course, a matter of conjecture. The earlier investigators seem to favor the conception that lymph stasis with consequent dilatation of the lymph vessels

by the blocking of lymph channels by inspissated chyle, with accompanying degeneration of adjacent lymph nodes. The presence of lymph-glandular tissue in most of these tumors has been used as an argument in favor of this conception. Westman very logically rejects the stasis theory on the grounds that (1) the numerous anastomoses in the lymphatic system would take care of any stasis through collateral circulation, and (2) it is not always possible to determine any anatomic-pathologic changes that might give rise to stasis. Recent investigators, notably Westman and others who have extensively studied this subject, apparently hold to the idea that these tumors are true lymphatic growths, possible of congenital origin.

Pathological examination of the specimen in our case showed the tumor not only to be composed of typical spongy lymphangiomatous tissue, but also in part to have a solid lymph-glandular structure. The presence of lymphoid tissue in certain organs undergoing pathologic change is not uncommon. Notable examples of this

are found in cases of chronic thyroiditis, where practically the entire thyroid gland is often found to be replaced by true lymph-glandular tissue, with typical germ centers showing mitotic figures, lymphoblasts and lymphocytes. Cases of Mickulicz' disease of the submaxillary gland and Kuttner's disease of the lacrimal gland also show the same presence of lymphoid tissue. Hashimoto<sup>12</sup> has demonstrated the presence of true lymphoid tissue in certain cases of a chronic inflammatory process in the gastric mucosa. Whether this lymphoid tissue is the result of chronic inflammation, or is simply a new growth it is impossible to say. It seems not improbable that lymphangioma of the mesentery would fall in the same category as these other lymphoid formations.

The clinical diagnosis of mesenteric tumor is practically an impossibility. There are no pathognomonic signs or symptoms. All writers agree that the abnormal mobility of the tumor, when palpated through the abdominal wall,

is the only fairly distinctive sign. It is stated that no abdominal tumor possesses the wide range of motion that mesenteric tumors do. This was certainly a striking feature in our case, it being possible to move the tumor through both the lower abdominal quadrants by palpation.

In the differential diagnosis one must consider mainly ovarian cyst, enlargement and displacement of the kidney, pedunculated fibromyoma, omental cyst, tumor of the bowel itself and pancreatic cyst.

Surgical exploration of the abdomen with the extirpation of the tumor is the procedure of choice. The mortality following operation as reported in the literature is high.

Begouin showed a mortality of 51.7 per cent in 29 collected cases, Vance 40.7 per cent in 27 cases, and Rawls 45.1 per cent in 13 cases. The necessity of intestinal resection greatly increases the risk. Injury to the mesenteric vessels with consequent interference with the circulation of the adjacent segment of bowel must be carefully avoided.

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# SARCOMA OF THE STOMACH

## REPORT OF FOUR CASES AND REVIEW OF THE LITERATURE\*

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**M**ALIGNANT new growths of the stomach other than those of an epithelial nature are relatively uncommon enough to be of interest to both the clinician and the pathologist. Our recent observation of 2 cases of gastric sarcomas served to awaken our interest in the tumor, and has led us to examine the records of the Charity Hospital of New Orleans, as well as to an extensive survey of the available literature on the subject. It is the purpose to here record our cases, and to present a discussion of the salient features of the condition, based principally on our survey of the literature.

### CASE REPORTS

**CASE I.** L. R. (C. H. 363-1) Negro female, aged thirty-five years, was admitted with the complaint of pain in the stomach of one year's duration. Past history negative. Physical examination revealed emaciation and a palpable epigastric mass. Laboratory examinations negative. The x-ray diagnosis was a "partial pyloric stenosis of malignant origin." At operation the pyloric end of the stomach was found to be diffusely thickened to an average thickness of 2 cm. with marked pyloric stenosis. There were dense adhesions to the pancreas and the regional lymph nodes were enlarged. The stomach was explored and closed, and a gland removed for histological study. The report of the pathologist on this tissue was sarcoma. The patient made an uneventful postoperative recovery and was dismissed from the hospital a few weeks later. No follow-up of the case was possible.

**CASE II.** R. F. (C. H. B7329) Negro female, aged fifty-six, was admitted with the complaint of a "lump in the stomach," which she had noted about a year ago. Physical examination revealed a palpable epigastric mass. At operation a large vascular tumor with many adhesions to the surrounding viscera was found springing from the greater

curvature. The tumor was resected and a gastrorrhaphy performed. The tumor weighed 850 gm. The report of the pathologist was "malignant leiomyoma with much hyalin degeneration." The patient made an uneventful postoperative recovery. Further developments in the case are unknown.

**CASE III.** J. R. (C. H. 633) white, male, aged sixty, was admitted with the complaint of severe epigastric pain of about eight months' duration. Physical examination revealed marked emaciation, and enlargement of the cervical and inguinal lymph nodes. The x-ray reported that there was a filling defect in the prepyloric portion of the stomach. At operation a dense infiltrating growth was found at the pylorus, which grossly appeared to be a scirrhous carcinoma. There was a mass of enlarged glands of dense consistency in the mesentery of the jejunum. A partial gastrectomy and a gastrojejunostomy were done. The patient died a few days later. The report of the pathologist was "round cell sarcoma."

**CASE IV.** M. H., aged fifty-six years, suffered from indigestion for the past year, accompanied by loss of weight. X-ray examination suggested an intragastric growth. At operation a tumor mass 800 gm. in weight and attached to the lesser curvature was found. Histological examination revealed it to be a spindle-cell sarcoma. The patient is in perfect health four years later. (Figs. 1 and 2.)

### HISTORICAL REVIEW

In 1847 Bruch recorded the first case of sarcoma of the stomach. Forty years later, Virchow reported on the first patient that came for operation. In 1900 Fenwick was able to gather 60 reported cases, and decided that 53 of these were adequately proved. In the following decade critical studies and case reports were made by Lecene and Petit, Corner and Fairbanks, Lafero, Azzurini and others. In 1914 Flebbe collected 157 cases based solely

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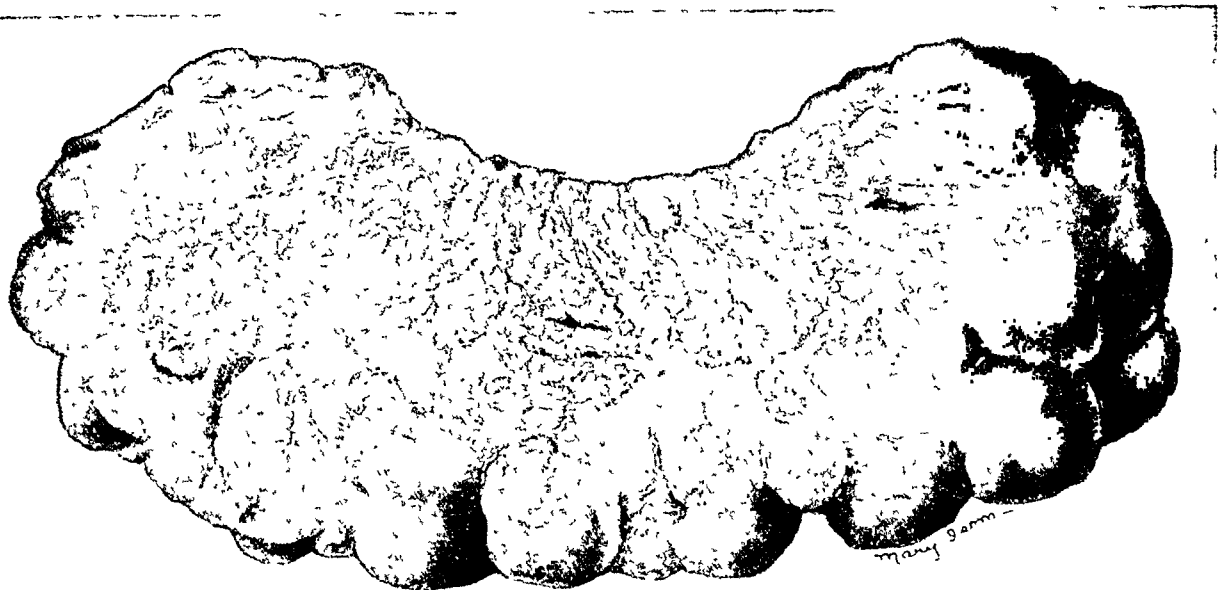


FIG. 1. Intragastric spindle-cell sarcoma. Case iv.

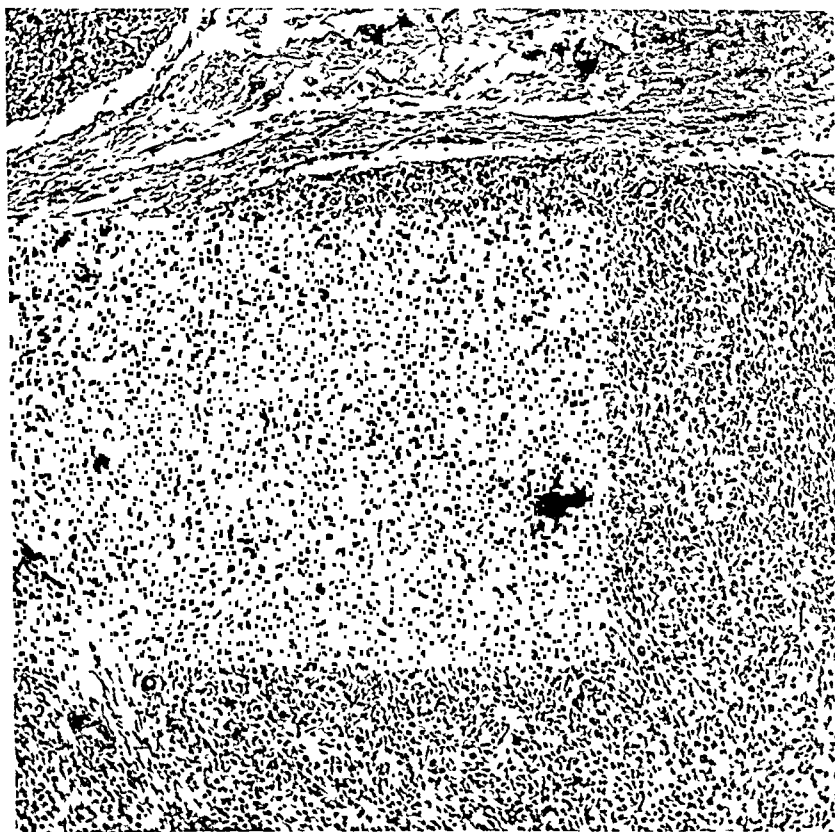


FIG. 2. Intragastric spindle-cell sarcoma. (Low power.) Case iv.

TABLE I

Author & Year	Age	Sex	Main Symptoms	Duration	Operation	Location of Tumor	Metastases & Recurrence	Histology of Tumor	Comments
Krichelski, S. A., 1913 Case 1	21	M	Abdominal pain & tumor. Diarrhea. Coffee-ground vomitus.	1 year		Diffuse in lower $\frac{2}{3}$ stomach wall	Pancreas.	Round-cell	Case 1. Nine days after admission to hospital died suddenly. No operation—autopsy.
Case 11	36	M.	Epigastric tumor	4 months	Resection Bill. roth II.	Pylorus.	Pancreas.	Round-cell.	Case II. Collapsed and died 3 days after operation. No autopsy.
Scudder, C., 1913	29	M.	Indigestion.	2 years	Partial gastrectomy with preliminary jejunostomy.	Endogastric posterior wall.		Spindle-cell.	Reported as well 6 months after operation.
Gossage & Hicks, 1913	37	M	Abdominal pain, dizziness, bloody vomitus & bloody stools.	17 days		Attached by narrow pedicle to middle of posterior wall.		Fibrosarcoma.	Death several days after admission to hospital. Autopsy.
Schiller, M., 1914	67	M.	Palpable abdominal tumor	9 years		Not stated.		Leiomyosarcoma.	The interesting thing about this case was the existence of a palpable tumor for 9 years. It may have been a myoma which became sarcomatous.
Kimpton, A. R., 1914	30	F	Palpable abdominal tumor. Indigestion.	20 years	Partial resection.	Not stated.	Regional lymph nodes.	Round-cell.	Living and well at time of report, 6 years after operation. A later report in 1919 states that patient was still living. That this was originally a leiomyoma which developed malignant properties, is suggested by the long duration of the tumor.
Frazier, C. H., 1914	36	F.	Vomiting & heartburn. Palpable abdominal tumor.	About 1 yr.	Gastric resection & posterior gastrotrojunostomy.	Greater curvature.	Jejunum. Regional lymph nodes.	Lymphosarcoma	Well 9 months later.
Hartz, H., 1914	41	M.	Indigestion pain in stomach. Nausea.	2 months	Exploratory laparotomy. Biopsy of omentum.	Anterior wall lesser curvature.	Gastrocolic omentum & head of pancreas.	Small round cell.	At operation inoperable tumor found, biopsy of metastasis to omentum for diagnosis. Death 16 days later. Autopsy.
diGiacoma, G., 1914 Case 1	65	M.	No clinical signs.			Near pylorus.		Round-cell	Case 1. Discovered at autopsy on patient dying of pulmonary

Case	Age	Sex	No clinical signs.	Pyloric region.	Small round-cell	tuberculosis, Chronic polypous gastritis present.
Case II	91	F.				
Storch, B., 1914 Case I	40	F	Dyspepsia. Epigastric pain. Palpable epigastric tumor.	Posterior surface lesser curvature	Round-cell.	Case I. Returned 9 months after operation with large recurrence at site and signs of metastases to liver. Dismissed as inoperable.
Case II	41	M.	Loss of weight and appetite bloody stools.	Greater curvature near pylorus.	Round-cell.	Case II. Developed fistula at operative site. Died about 6 months later. Autopsy.
Case III	58	M.	Pain in stomach.	Posterior wall near pylorus.	Glands in gastro-hepatic ligaments.	Case III. The stomach wall also contained a benign mucous membrane fibroids operated about 6 months previous to report, and no mention made other than "uneventful recovery."
Case IV.	37	M.	Loss of appetite constipation, epigastric tumor.	Location in stomach not given.	Lymphosarcoma	Case IV. Died about 2 weeks after exploratory laparotomy. Autopsy. A clinical diagnosis of tuberculous peritonitis had been made.
Burty, 1914	58	F.	Palpable abdominal tumor.	Attached by pedicle to lower part of greater curvature.	Angiosarcoma.	Uneventful recovery, and well at time of report, about 6 months after operation.
Schlesinger, H., 1915	17	F.	(Note cases reported by diGiacoia in 1915 were same as those reported in 1914.) Vomiting and other symptoms of pyloric stenosis.	Pylorus.	Lymphosarcoma.	An unusual feature of this case was the fact that it produced a pyloric stenosis, which sarcomas, particularly of this type seldom do.
Venturelli, G., 1915	71	F.	Abdominal pain, dizziness.	Greater curvature.	Omentum.	Patient stated that her symptoms dated from a blow which she received in her left flank.
Scott & Forman, 1916	53	M.	Weakness & abdominal pain.	General infiltration of stomach wall.	Regional lymph nodes.	Died 2 days post-operative. This case was autopsied and



TABLE 1 (Continued)

Author & Year	Age	Sex	Main Symptoms	Duration	Operation	Location of Tumor	Metastases & Recurrence	Histology of Tumor	Comments
Scott & Forman, 1916 (Continued)					for diagnosis.				primary neoplastic process was found to be in stomach. It is reported as a case of Hodgkin's disease of stomach. Pathologists report on tissue removed at laparotomy was "malignant lymphoma."
Barrington-Ward & Shaw, 1916	25	M.	Indigestion.	5-6 years.	Resection partial gastrectomy.	Pedunculated attached to anterior & posterior walls near pylorus.	None seen.	Round-cell.	Well at time of report 4 months after operation.
Bachrach, R., 1916	39	F.	Nodule in gastric region, later became mass.	12 years.	Resection of portion stomach wall where tumor attached.	Pedunculated attached at upper pole & greater curvature.		Malignant myoma.	Uneventful recovery dismissed as cured 14 days after operation. Discussion of the possibility of this tumor having had its start as a benign growth which underwent sarcomatous changes.
Schlesinger, H., 1916	32	M.	Gastric pain vomiting of solid food, symptoms occurred only occasionally.	7 years.		Lesser curvature, posterior wall.	Liver, spleen left kidney.	Lymphosarcoma.	Discovered at autopsy.
Case 11	66	M.	Loss of appetite emaciation, vomiting.	18 months.	Exploratory laparotomy.	Greater curvature, central between cardia and pylorus.	Lymphatic glands of lesser curvature, liver left suprarenal.	Lymphosarcoma.	Case 11. At laparotomy found inoperable. Died a few days later. Autopsy.
Saito, J., 1916	27	F.	No definite clinical symptoms.			Lesser curvature from cardia to pylorus.		Carcinosarcoma.	Discovered at autopsy. Author states that the cases of Queckenstedt (1904) Lippmann (1904) & Lindemann (1908) were of the same histological type as his own.
Rhodenburg, G., 1917	No details reported							Fibromyosarcoma.	
Medina & Egana, 1917	37	M.	Epigastric pain.	6 months.	Gastric resection.	Lesser curvature.		Called round-cell sarcoma by 3 pathologists, and fibrosarcoma by one.	

		F.	Epigastric pain.	1 year.	Gastric resection.	Prepyloric region.	Fibrosarcoma.	Death 9 days after operation. Autopsy. Perforation with death due to peritonitis. Question of malignant degeneration of benign myoma.
Geymuller, E., 1917.....	40							
Fritzsche, R., 1918.....	39	M.	Occasional epigastric pain, bloody vomitus, and bloody stools.	3 years.	Laparotomy at times of perforation. Drainage of peritoneal cavity.		Leiomyosarcoma.	
Details of case not obtained								
Schroeder, R., 1918.....								
Pagenstecher, G. A., 1919.....	43	F.	Rapidly growing abdominal mass.	1 month.	Exploratory laparotomy.	Anterior wall.	Myosarcoma	Died 12 days after operation. Autopsy established diagnosis. Living and well 6 years later.
Holmes, T. W., 1919.....	48	M.	Sense of oppression in epigastric.	1 month.	Resection.	Greater curvature.	Fibrosarcoma.	
McWhorten, G. L., 1919.....	45	M.	Abdominal swelling.	7 months.	Exploratory laparotomy with removal of 2500 c.c. clear fluid.	Greater curvature.	Round-cell & spindle-cell sarcoma.	Died 10 days after operation. Autopsy. No metastases noted.
Koettlitz, H., 1919.....	31	M.	Abdominal tumor. Indigestion.	1½ years.	Inoperable tumor discovered at exploratory laparotomy. Tissue for diagnosis removed.	Generalized infiltration in all but cardiac portion.	Fibrosarcoma.	Died 1 month after operation.
Loeper, M., 1919.....	?	M.	Abdominal tumor and pain. Vomiting.	2 months.		Anterior wall.	Round-cell.	Died 4 months after onset symptoms.
Noordenbos, 1919.....	17	F.	Recurrent hemorrhage.	3 years.	Subtotal gastric resection.	Lesser curvature	Spindle-cell.	Good postoperative recovery.
Brasch, S., 1920.....	22	F.	Gastric distress.	1 year.	Complete resection.	Pyloric end.	Large round-cell.	Condition good 15 months later.
Douglas, J., 1920.....	38	F.	Mass in abdomen pain.		Resection pyloric end.	Pyloric end greater curvature.	Lymphosarcoma.	Died 24 hours after operation.
Case I.....	41	F.	Epigastric pain.	2 years.	Resection pyloric end.	Pyloric end.	Lymphosarcoma.	Died 23 days after operation.
Case III.....	36	M.	Epigastric pain.	3 months.	Resection.	Posterior wall.	Lymphosarcoma.	Well 16 months later.
Haggard, W. D., 1920.....	17	F.	Mass in abdomen hemorrhage.	1 year.		Lesser curvature.	Fibromyosarcoma.	Well at time of report 20 months after operation.
Author's case.....								
Reports following 13 cases from Mayo Clinic—1908 to Aug. 1920.								
1. Case 18165.....	38	F.	Abdominal tumor.	3 years.	Partial gastrectomy.	Greater curvature.	Fibrosarcoma.	Died 6 months later.
2. Case 53972.....	62	M.	Epigastric pain.	4 years.	Exploratory laparotomy. Removal of gland.	Fundus.	Sarcoma.	Condition "poor" 4 months after operation.
3. Case 82074.....	44		Epigastric pain abdominal tumor.	4 weeks.	Resection.	Greater curvature.	Spindle-cell.	Well 4 months later.
4. Case 182060.....	16	M.	Continuous epigastric pain.	4 months.	Partial gastrectomy.	Posterior wall.	Lymphosarcoma.	Development unknown.

TABLE I (Continued)

Tumor of pancreas. .... 1 case  
Pyloric obstruction. .... 1 case  
6. Operations: 6 resections; 6 found inoperable at exploratory laparotomy.  
7. Results:  
2 resected cases died of peritonitis.  
1 died 4 months later with recurrence.  
1 died 5 months later with recurrence.  
1 returned 7 months later with recurrence.  
4 of 6 who had exploratories died 6 weeks to 4 months later.  
Information regarding others not obtained 1 case.

Simon, 1921 .....	Reports case of spindle-cell sarcoma of greater curvature. In discussion of same paper Marklewitz reports same type in female aged 65, no gastric symptoms, picture dominated by large liver metastases.									
Cutler, E., & Smith 1922. . . . . Case 1.	59	M.	Nausea & weakness.	7 months.	Exploratory laparotomy.	Lesser curvature.	Regional lymph nodes. Diaphragm pericardium pancreas.	Lymphosarcoma.	Died shortly after exploratory. Autopsy.	
Case 2	57	M.	Epigastric tenderness.	7 months.	Resection.	Whole of stomach wall.		Lymphosarcoma.	Well 1 year later at time of report.	
Gillette, W. J., 1922. . . . .	45	M.	Epigastric pain, bloody vomitus & stools.	3 months.	Resection.	Lesser curvature.		Lymphosarcoma.	Well at time of report about 14 months later.	
Finsterer, H., 1922 . . . . .	54	M.	Pain, vomiting abdominal tumor.	1½ years.	Resection.	Pyloric portion of stomach.	Liver.	Polymorphous cellular.	This tumor developed after an operation for eliminating duodenal ulcer about 2 years previously.	
Kolbe, H., 1922.....	51	M.	Vomiting, abdominal tumor.	6 months.		Pyloric region.		Fibrosarcoma.	This tumor perforated 6 months prior to death producing an abscess of the abdominal wall which finally caused death by general peritonitis. Autopsy.	
Schindler, R., 1922.....	60	F.	Vomiting, diarrhea.	Several months.		Anterior wall.	Periaortic, pancreatic perigastric lymph nodes.	Lymphosarcoma.	Death. Autopsy. Between ages of 20 to 30 patient had signs and symptoms of gastric ulcers with hemorrhage and had been successfully treated for same.	
Ruffin, R., 1923.....	60	M.			Resection.	Both walls & both curvatures.	Liver, pancreas, regional lymph nodes at hilum of left lung, recurrence at site.	Lymphosarcoma.	Death 5 months later with recurrence at site and metastases.	
Pistocchi, G., 1923.....	50	M.	Asthemia, vomiting.	4 months.		Greater curvature, anterior surface.	Liver.	Lymphosarcoma.	Death 5 months later. Symptoms dated from an abdominal trauma. Was this an etiological factor?	
Charrier, A. & Rion, 1923.....	63	M.	Loss of weight, indigestion.	5 months.	Resection.	Anterior surface near pylorus.		Malignant fibrochondroma.	Recovered from operation and dismissed in 18 days. Further results not given.	

TABLE 1 (Continued)

Author & Year	Age	Sex	Main Symptoms	Duration	Operation	Location of Tumor	Metastases & Recurrences	Histology of Tumor	Comments
Harding, D. B., 1924.....	16	M.	Abdominal mass, pain.	4 months.	Resection.	Posterior wall.	.....	Lymphosarcoma.	Death 1 month later.
Lassila, V., 1924.....	69	F.	Abdominal tumor below umbilicus. Indefinite abdominal disturbances.	4 months.	Resection.	Posterior wall near pylorus.	.....	Small round-cell sarcoma.	Free from recurrence and well at end of 4 years.
Thatcher, H., 1924.....	77	M.	Weakness epigastric tumor.	3 months.	.....	Cardiac portion, greater curvature.	Liver.	Spindle-cell.	Death 3 days after admission to hospital autopsy.
Klaus, H., 1924.....	49	M.	.....	4 months.	Resection.	Lesser curvature, posterior wall.	.....	Myofibro-sarcoma.	Well 1 year later.
Lindboe, E., 1924.....	36	M.	Indigestion, bloody stools.	2 years.	Surgical removal.	Posterior wall.	.....	Myofibro-sarcoma.	Died 15 months later in an accident.
Case I.....	31	M.	Pain nausea vomiting.	Few months.	Polya resection.	Posterior side, distal half.	Recurrence, gland vature.	Round-cell.	Died of recurrence 6 months later.
Author mentions 3 other cases observed in Norway. No details save age and sex:									
Case III.....	Elderly	M.	.....	.....	.....	.....	.....	.....	.....
Case IV.....	37	F.	.....	.....	.....	.....	.....	.....	.....
Case V.....	57	F.	.....	.....	.....	.....	.....	.....	.....
Demel, R., 1924.....	8	F.	.....	.....	.....	Pedunculated on stomach.	.....	.....	This tumor perforated before resection.
Sebestyén, G. & Kaló, A., 1924.....	41	F.	Pain.	2 months.	.....	.....	Retropertitoneal lymph nodes.	.....	Death 5 months later.
Kapel, O.....	38	F.	Abdominal tumor, melen, pain.	10 years.	Resection of stomach & transverse colon.	Anterior & posterior walls.	Mesocolon. Recurrence at site with metastases in mesentery of small intestine and liver.	Round-cell.	6 months after 1st operation a second revealed inoperable recurrence after first operation.
Meischke, M., 1925.....	30	F.	Anemia tumor above umbilicus.	.....	Partial gastrectomy.	Posterior wall.	.....	Spindle-cell.	Anemia but no signs of recurrence when last heard of 1 month later.
Straus, Black & Hamburger, 1925.....	.....	M.	Emaciation, anemia.	.....	Resection.	Involved 80% stomach wall.	.....	Lymphosarcoma.	Well 4 years later.
Case I.....	48	F.	Indigestion mass in abdomen.	.....	Resection.	Greater curvature.	Regional lymph nodes.	Lymphosarcoma.	Well 4 months later.
Case II.....	33	.....	Abdominal mass.	.....	Resection.	Diffuse involvement entire wall.	.....	Lymphosarcoma.	Died 5 days later post-operative.
Chand, W., 1926.....	28	M.	Loss of weight.	6 months.	.....	Cardiac end, greater curvature.	Regional lymph nodes left kidney.	Lymphosarcoma.	Diagnosis established at autopsy.
Farr, C. E., 1926.....	34	M.	Epigastric pain.	6 months.	Resection.	Posterior wall lesser curvature.	Regional lymph nodes.	Lymphosarcoma.	Well 3 years later.

Case II.	38	M.	Epigastric pain.	1 day.	Resection.	Anterior surface lesser curvature.	Recurrence at site.	Spindle-cell.	Died 1½ years later.
Chandler, I., 1926.	38	F.	Mass in abdomen weakness.	6 months.	Resection.	Attached to greater curvature posteriorly by pedicle.	.....	Round-cell.	Well 7 months later. Patient thought she was pregnant and noted growth of tumor for 6 months.
Report 8 cases of sarcoma of stomach seen at Massachusetts General Hospital—No detailed information given. Seven will be counted in this report, as one at autopsy proved not to be primary in stomach.									
Dahs, W., 1926-1927.	16	F.	Pain in gastric region.	6 months.	Resection.	Anterior wall.	Regional lymph nodes.	Fibromyxosarcoma.	Condition good at time of publication about 5 years later.
Brander, H., 1927.	27	M.	Indigestion.	3 months.	Resection.	Entire gastric wall except cardiac portion.	Regional lymph nodes.	Myxosarcoma.	Died 10 days after operation.
Greck, I., 1927. Case I	44	F.	Tumor in upper abdomen, pain nausea vomiting.	4 months.	"Surgical removal."	"Connected with gastric wall."	.....	Sarcoma.	Fate of patient unknown.
Case II.	42	M.	Tumor in skin and abdomen pain, nausea & vomiting.	5-6 weeks.	Removal of skin tumor for diagnosis.	Pyloric region.	Skin and mesentery.	Sarcoma.	Autopsy.
Case III.	42	M.	Abdominal tumor pain.	6 months.	Operation refused.	.....	.....	Sarcoma.	Autopsy.
Kahan, M., & Seidenburg, A., 1927	23	M.	Epigastric pain.	2 years.	Resection.	Middle and lower thirds of stomach.	Regional glands and lesser curvature.	Alveolar large round-cell.	This tumor perforated. Death a few hours after operation. Autopsied.
Djorup, F., & Okkels, H., 1927.	28	F.	Anemia.	.....	Resection.	Posterior wall greater curvature.	.....	.....	.....
Bamber, J. M., 1927.	19	F.	Vomiting epigastric pain.	18 days.	Resection.	Middle lesser curvature.	Recurrence at site.	Round-cell sarcoma.	Died with recurrence about 2 years later.
Jeffries, J. F., 1927.	31	M.	Pain in stomach.	6 months.	Partial gastrectomy.	Pyloric end.	Liver.	Large round-cell.	Two and one-half months later metastases could be palpated in liver. Developments unknown.
O'Callaghan, R. H. L., 1927.	54	F.	Indigestion, melena, weight loss.	Few months.	Exploratory with tissue biopsy for diagnosis.	Both curvatures.	None noted.	Sarcoma.	Death 2 weeks after operation.
Cumston, G., 1827. States that he operated on authenticated case, sarcoma of stomach proved microscopically. No details given.									
Bastianelli, P., 1927. Case I	27	M.	Indigestion, tumor at umbilicus.	6 months.	Subtotal resection.	Fundus, antral and pyloric regions.	Recurrence at site.	Small round-cell.	Death seven months later with local recurrence.
Case II.	28	F.	Pain & abdominal tumor.	4 months.	Resection.	Greater curvature.	Local recurrence.	Small round-cell.	Death 6 months later.
Case III.	30	F.	.....	6 months.	Resection.	From duodenum to cardia.	Local recurrence.	Sarcoma.	Died 9 months later.
Hartman, H., 1927.	48	M.	Mass in epigastrium, weakness.	2 months.	Resection.	Posterior wall.	Liver, diaphragm.	Fibromyxosarcoma.	Died 18 days post-operative. This tumor presented in stomach of a case of neurofibromatosis

TABLE I (Continued)

Author & Year	Age	Sex	Main Symptoms	Duration	Operation	Location of Tumor	Metastases & Recurrences	Histology of Tumor	Comments
Hartman, H., 1927 (Continued)									(von Recklinghausen's disease and presumably arose in a neurofibroma of stomach)
Schlosser, W., 1928	29	F	Epigastric tumor and pain	1 month	Exploratory laparotomy	Lesser curvature with infiltration whole stomach	Regional lymph nodes left kidney, pancreas	Lymphosarcoma	Death 8 hours after operation this case gives history of trauma. Was struck in abdomen by chair fracturing 2 lower right ribs 18 months previous to onset of symptoms. Author does not consider this an etiological factor.
Cavina, G., 1928	53	F	Tumor upper right quadrant		Gastrectomy	Posterior surface greater curvature		Spindle-cell	Well at end of 8 months. This tumor was extrinsic attached by pedicle lying between stomach and transverse colon.
Bullock, H., & Sherman, C., 1928	60	F	Indigestion	8 years	Resection	Diffuse in gastric wall		Round-cell	Condition good 5 months later
Therstappen, F. J., 1928	..	..	..	..	Resection	Exogastric		Sarcoma of embryonic undifferentiated muscle tissue.	Death 25 days post-operative
Gunnett & Oberling	48	M.	Malnutrition	... ..	Anterior gastrectomy.	Pyloric region	Regional lymph nodes	Lymphosarcoma	Well at end of 5 years.
Freeman, L., 1928	60	M.	Indigestion	2 years	Resection	Diffuse in wall of transverse portion.	Regional lymph nodes	Lymphosarcoma	Well at end of 17 months. Received deep x-ray therapy and colostomy after operation.
Hall, J. S., 1928	40	M.	Pain after eating.	.....	Resection	Middle of stomach	Regional lymph nodes.	Round-cell sarcoma	Well 4 months later.
Smith, A., 1928	20	M.	Pain & tumor in left abdomen.	5 months	Exploratory removal of gland for diagnosis.	Involvement whole gastric wall except cardia & pylorus.	Regional lymph nodes.	Sarcoma	Died 3 weeks post-operative.
Heslop, A., 1928	32	M.	Epigastric pain.	Several weeks.	Resection.	Pedunculated attached lesser curvature.		Sarcoma.	Well at time of report a few months later
Jaki, J., 1928	23	F.	Tumor in region of pylorus, pain.	2 weeks.	Resection.	Anterior wall.	Glands in gastrocolic ligament	Undifferentiated sarcoma.	Well 6 months later.
Villata, M., 1928	.....	M.	Occasional vomiting & blood stools, loss of	1 years.	Resection of pylorus.	Pyloric portion.	Regional lymph nodes	Sarcoma originating in reticulo-endothelium	Author is discussing specimen sent to him severe trauma in ab-

			weight.					lial cells.	domen preceded symptoms by 1 month. There was a chronic ulcer, which author thinks followed the trauma and the irradiation of this initiated pathological changes resulting in tumor.
Pemberton, J., 1929.....	54	F.	Abdominal mass.	7 years.	Resection & pyloroplasty.	Lesser curvature.	.....	Fibrosarcoma extensive.	Well at time of report a few days after dismissed from hospital.
Curtis, G., & Delaney, P., 1929.....	59	F.	Severe secondary anemia.	.....	Resection & gastrectomy.	Pylorus.	.....	Leiomyosarcoma.	In good condition 7½ months later.



on autopsy findings. In the same year, Forni made the most complete and detailed analysis of these tumors which we have been able to find. He brought the total of the reported cases up to 200. In the preceding year and in the same year, we were able to find the report of several cases not included by Forni in his analysis. We have added these cases to those presented by him and have listed the cases reported since that time. The total number of these tumors recorded in the literature through 1929, including those which we now add, is 335. Table 1 presents the salient features of the cases we have reviewed.

#### FREQUENCY

Sarcomas form only a small percentage of the new growths of the stomach. Various authors, however, have given estimates of their comparative frequency which range from 1 to 8 per cent. Fenwick states that sarcomas occur in 5 to 8 per cent of stomach tumors. Yates made a study of 800 tumors of the stomach and found that 2 per cent of the cases were sarcomas. Ewing estimated their frequency at 1 per cent. Ziesche and Davidsohn in 1909, from the statistics of various German operative clinics and their autopsies, estimated that 1 per cent of the tumors of the stomach are sarcomas. Douglas reported that in a period of eight and a half years (January 1, 1911 to July 1, 1919) there were 702 cases of carcinoma of the stomach diagnosed at Bellevue Hospital, while at the time of his report (1920) the operative records of the Hospital contained only 2 cases of gastric sarcomas. In studying 921 cases which had been diagnosed as gastric cancer, Smithies and Ochsner found 4 sarcomas. Haggard stated that in 27,250 abdominal sections at the Mayo Clinic in five years there were 8 sarcomas of the stomach (Masson) and of 2067 malignancies of the stomach (1908-1920) 13 proved to be sarcomas, or there was 1 sarcoma to 159 carcinomas of the stomach. Brasch called attention

to the fact that statistical figures regarding this growth are merely relative, since many cases are assumed to be carcinoma or chronic inflammatory changes associated with chronic gastric ulcer, while subsequent careful histological examination proves them to be sarcomas. He added that Perry and Shaw in going over a series of cases from Guy's Hospital which had been reported as carcinomas, found 4 cases which were really round-celled sarcomas.

The records of the Charity Hospital of New Orleans, from 1906-1929 include 642 diagnoses of sarcoma. Of these sarcomas, 3 were gastric. During this period there were 341 diagnoses of gastric carcinomas. From these records, we may conclude that in this part of the country gastric sarcomas form about  $\frac{1}{2}$  per cent of all sarcomas, and about 1 per cent of all malignancies of the stomach.

#### ETIOLOGY

The specific etiology of sarcomas of the stomach as with all malignant conditions is at this state of our knowledge unknown. We can therefore under this subject, discuss only such factors as have been mentioned as contributing to, or playing a rôle in their development. Such factors are principally trauma, preexisting non-malignant tumors and ulcers, age and sex.

We note a number of cases of gastric sarcoma (Robert, Brooks, Ziesche, Pistocchi, McWhorten, Venturelli, Schlosser, Villata) in which the patients dated the onset of their symptoms to trauma which they suffered. The various authors reporting these cases differ as regards their opinions as to the importance of trauma as an etiological factor. Thus in one case (Pistocchi) a man was perfectly well until he was thrown from a wagon and seriously bruised on the front of the thorax at the height of the last rib. A diagnosis of fracture of the ninth and tenth ribs was made. The pain which developed at the time became increasingly severe and settled in the stomach. Within

two months digestive disturbances appeared, while three months later, pathological changes in the stomach were demonstrated by roentgen ray. The patient died at the end of five months, subsequent autopsy revealing a well developed intragastric, infiltrating lymphosarcoma with metastases to liver, regional lymph nodes and diaphragm. The author remarks that while there is no way of proving that the growth did not exist previous to the trauma, this latter merely serving to awaken it, he is of the opinion that it was probably caused by the trauma. Venturelli reports a case of a woman aged seventy-one who had been in an excellent state of health until she was struck in the left flank with the handle of a broom. Pain, vomiting, loss of appetite, rapidly progressive cachexia ensued, and she died within one month from the date of the trauma. Autopsy revealed a well developed lymphosarcoma of the stomach. The author makes no comment as to the importance of the trauma as an etiological factor. In Villata's case severe abdominal trauma preceded the onset of symptoms by one month. Four years later at autopsy the stomach revealed a chronic ulcer, with a sarcoma originating in the reticulo-endothelial cells. The authors consider that the ulcer was initiated by the trauma, and that irritation of this ulcer produced pathological changes resulting in the malignant condition. In Schlosserer's case the patient suffered abdominal trauma eighteen months previous to the onset of symptoms. He does not consider that this was an etiological factor.

Numerous observers report cases in which they feel that benign myomatous growths have taken on malignant properties. Schiller, Kimpton, Fritzsche, Bachrach, and Warner all report cases in which a tumor which was known to have existed for years without causing any symptoms, suddenly began to display malignant features and on removal and histological examination proved to be a sarcoma. Warner states that "just as sarcoma

may engraft itself upon a leiomyoma of the uterus, so a like tumor of the stomach may undergo a similar behavior." He furthermore points out that gastric leiomyosarcoma occurs frequently at the same period of life (between thirty and fifty years) that malignant leiomyoma of the uterus develops. Buchrach states that while benign myomata of the gastrointestinal tract are rare, in 1898 the medical literature contained reports of 51 such tumors. He states that in the gastrointestinal tract pure leiomyoma occur, while the corresponding tumors of the uterus are mainly myofibroma, but that in each instance, in an identical manner, the tumors seem to be able to take on malignant properties. Bullock (quoted by Haggard and Fenwick) in writing on benign tumors of the stomach says, "We have not been able to find a single case in the whole literature where a large tumor of the gastric wall was above suspicion of malignancy." In strong contrast to this opinion, is that of Gosset, Bertrand, and Lowey, who upheld the opposite thesis. Of interest in this connection is a case reported by Hartman in which a fibromyosarcoma of the stomach occurred in a case of von Recklinghausen's disease, the author concluding that it had originated in a neurofibroma. Osler, in discussing von Recklinghausen's disease, states that the neurofibroma of internal organs may develop sarcomatous changes.

Several writers have questioned the possible origin of a gastric sarcoma from the connective tissue elements of a chronic ulcer. The case of Villata has been previously referred to. Willensky quoted Moser and Kehr to the effect that it is possible for gastric sarcoma to follow ulcer, but says that the relationship is still open to question as it has not been satisfactorily proved. Finsterer reports a case which is interesting in this respect. A man who had suffered gastric disturbances for years was operated on for a duodenal ulcer, at which time a resection of the stomach was done, due to dense adhesions. Two

years later the blindly closed pyloric portion of the stomach was found to contain a polymorphous celled sarcoma which was resected and which caused death by metastases some months later. The value of this instance is lessened, however, by the fact that the specimen from the first operation was not subjected to histological examination. Schindler reports a case in a man of sixty years where death ensued after gastric symptoms of several months' duration. A well developed lymphosarcoma was revealed at autopsy. Between the ages of twenty to thirty this man had suffered with typical signs and symptoms of gastric ulcer with hemorrhage. He received treatment for such a condition and made a recovery. The author concludes that this was a case of sarcoma which developed in a stomach which had been the site of an ulcer. In a case reported by di Giacomina the patient died of advanced pulmonary tuberculosis. At autopsy a round cell sarcoma of the stomach was found, associated with a condition of chronic polypoid gastritis. Stanley Wyard says, referring to gastric sarcoma, "There does not appear to be any connection between them and simple ulcer, though it is possible that irritation may play some part in their production."

While we do not feel that any of the cases which we have cited show conclusive etiological relationship between chronic gastric ulcer and gastric sarcoma, it is our opinion that such a relationship is at least theoretically possible. An ulcer can undoubtedly stimulate prolonged connective tissue formation, and such chronic reactions to irritations have been shown conclusively to act as etiological factors in the production of malignant processes in other regions.

As regards age, the cases reported in the literature have ranged from three and one-half, (Finlayson) to ninety-one years (di Giacomina). Several authors state that the age of greatest incidence is forty to fifty years (Haggard, Garnor and Fairbanks quoted by Frazier). Hertzler, quoted by Warner, says that the disease is so

distributed that it cannot be considered a disease of any special age. Scudder says that it is a "disease of the young." Ewing states that the lymphosarcomas occur chiefly in young subjects. Forni estimates that the age of greatest frequency is from forty to sixty years, the average age for the lymphosarcoma being thirty-six years. Chandler in 1926 finds the most common age of occurrence of gastric sarcoma to be 41.6 years, and mentions that according to the last United States census the average age for gastric carcinoma is 61.2 years. Meischke disagrees with Bohmansson's statement that gastric sarcomas "generally occur after forty," and says that most of the cases reported have been in patients under that age. Broders and Mahle in a series of 12 cases of lymphosarcoma found the average age to be 46.25 years, the youngest case being sixteen and the oldest sixty-two. In the series of 135 tumors which we have studied the youngest age was eight years (Demel) while the oldest was eighty-one years (di Giacomina). The average age at onset of symptoms was 36.7 in these cases.

As regards sex, many authors make the statement that there is no special sex predominance in gastric sarcoma (Meischke, Chandler, Douglas). Haggard found that the sexes were equally divided in a series of 66 cases. On the other hand, Broders and Mahle in a series of 12 cases found 11 males. In the 135 cases we reviewed, 73 were males, 43 were females, and in 21 cases we were unable to obtain information regarding sex.

#### PATHOLOGY

Sarcomas of the stomach are generally grouped accordingly to form into the following types:

- Infiltrating, (diffuse, nodular or limited)
- Endogastric
- Exogastric

Lecène and Petiti accept the following principal types.

1. Diffuse infiltrating form.
2. Nodular form with multiple nodules invading all of the gastric wall.

- 3. An infiltrating, but limited form.
- 4. A pedunculated or sessile form over a small portion of the gastric wall.

They add that the first 3 of these forms bear a strong resemblance to carcinoma and are difficult to differentiate grossly. The fourth is a special form of sarcoma and the most frequent of all. We feel that the first classification is a simple workable one, and is the one on which we shall base our discussion.

From a histological point of view, gastric sarcomas are generally said to arise in the submucosa and to then invade the muscular stratum, usually respecting the gastric mucosa and serosa. When the gastric mucosa is affected by this form of malignancy, it is generally due to pressure necrosis and loss of blood supply, rather than to neoplastic invasion.

The tumors may arise from:

- 1. Connective tissue, true fibrosarcomas.
- 2. The smooth muscle cells of the wall of the stomach, leiomyosarcoma or malignant leiomyblastoma.
- 3. The lymphoid nodules, malignant lymphoblastoma, lymphosarcoma or Hodgkin's disease.
- 4. Endothelial cells of blood vessels or lymph channels, endothelioma, hemangio-endothelioblastoma.

In the series of 135 reports we have studied, histological classification of the tumors appeared 100 times, divided as follows:

Lymphosarcomas . . . . .	39
Round-cell sarcomas . . . . .	24
Spindle-cell sarcomas . . . . .	7
Fibrosarcomas . . . . .	7
Myosarcomas . . . . .	6
Round and spindle-cell sarcomas . . . . .	2
Leiomyosarcomas . . . . .	2
Fibromyxosarcomas . . . . .	2
Carcinosarcoma . . . . .	1
Undifferentiated sarcoma . . . . .	1
Sarcoma originating in reticulo endothelial cells . . . . .	1
Fibroneurosarcoma . . . . .	1
Fibromyosarcoma . . . . .	1
Mixed-cell sarcoma . . . . .	1
Angiosarcoma . . . . .	1
Fibrochondrosarcoma . . . . .	1
Myxosarcoma . . . . .	1
Polymorphous-cell sarcoma . . . . .	1

Forni, in his survey, reported the following histological types of growth:

Round-cell sarcoma . . . . .	98
Spindle-cell sarcoma . . . . .	72
Particulate-structure sarcoma . . . . .	39
Polymorphous-cell sarcoma . . . . .	14

It is to be emphasized as Simon noted in his report that giant-cell and so-called melanosarcomas have not been reported as encountered in the stomach.

As a rule, it may be said that the lymphosarcomas comprise the infiltrating types of growth. They frequently occur in young individuals and offer the worst prognosis of any of the types because, due to their form, they are not so easily extirpated surgically, and are therefore more prone to recur. They also metastasize more readily and at an earlier period in the progress of the tumor. Warner states that this is because of the smallness of the individual cells comprising the tumor, as well as their ameboid properties, thus making it easy for them to enter and diffuse themselves in the various lymphatic spaces. Whether or not cases of Hodgkin's disease should be cited as sarcomas of the stomach depends on whether this disease is considered to be of neoplastic or inflammatory origin. If Hodgkin's disease is of a neoplastic nature it may be considered as a scirrhus lymphosarcoma. A number of authorities adhere to this view. Forman and Scott call attention to the fact that lymphosarcoma of the stomach may be hard to differentiate from other forms of lymphoid overgrowth, especially from glands involved by chronic lymphoid leucemia or aleucemic leucemia, and state that it is only by proper evaluation of clinical data and the relation of the lymphoid overgrowth to the rest of the organism, and the careful study of microscopical sections taken from many portions of the tumor, that a diagnosis of lymphosarcoma can be made. diGiacoma notes that sarcomas of the round-cell type are frequently included in the groups of lymphosarcomas. Warner states in this regard that any round-cell sarcoma bears

the same appearance, and that careful examination with differential stains may prove a specimen which appears to be lymphosarcoma to be either a derivative of smooth muscle fibers or fibroblasts. Rapidly growing and very cellular leiomyosarcomas and fibrosarcomas present small opportunity for complete differentiation of cell types, and may show round cells, not characteristic of their origin. Warner cautions that this fact should be borne in mind, as otherwise one might pronounce the neoplasm a round-celled sarcoma when in reality the growth might be a leiomyosarcoma, fibrosarcoma or lymphosarcoma.

The endogastric and exogastric forms of tumor are more likely to be of histological types other than lymphosarcoma. Cumston states that the exogastric type is the commonest type of sarcoma of the stomach and therefore most interesting to the clinician. These tumors are comparable to other forms of malignancy of benign nature. They metastasize very slowly and are frequently very easily extirpated surgically by cutting off their pedicle. Gosset, Bertrand and Lowey, writing in regard to the pedunculated form of gastric tumors called sarcomas, state that they are in reality clinically and anatomically benign tumors developing at the expense of the neuromuscular apparatus of the stomach, and implantation. Fritzsche, on the contrary, states that thorough histological study of myomatous tumor of the stomach either pedunculated or broad-based would reveal areas of malignancy in the vast majority of cases.

The endogastric type of sarcoma is much less frequent than the infiltrating and exogastric varieties. Bertrand in a series of 70 cases, found only 4. These tumors usually develop beneath the mucosa, pushing it up and at length causing ulceration and sometimes hemorrhage. Cumston states regarding tumors of this type that they are often extremely soft, sometimes even diffuent. When a

cross section is made, the cut surfaces look lardaceous, while foci of necrosis and interstitial hemorrhage are detected.

In studying the location of gastric sarcomas it is noted that they do not tend to invade the orifices as do gastric carcinomas. In an analysis of 146 cases, Flebbe found the growth to be located at the pylorus, in 37 cases; greater curvature, 30 cases; posterior wall, 26 cases; lesser curvature, 13 cases; anterior wall, 8 cases; cardia, 3 cases; pylorus and both curvatures, 2 cases; while in 27 cases almost the entire stomach was infiltrated. Cumston says: "From what very little we know, it may be said that sarcoma of the stomach usually respects the gastric orifices which, on the contrary, carcinoma usually invades from the two curvatures and anterior and posterior gastric walls." Brasch states that "while observers differ, the majority agree that the curvatures, especially the greater, are the most frequent sites of origin."

In the cases we surveyed, the location of the tumor was mentioned 100 times as follows:

Greater curvature.....	17
Pyloric region.....	16
Lesser curvature.....	16
Posterior wall.....	12
Diffuse infiltration.....	11
Anterior and posterior wall.....	11
Anterior wall.....	6
Anterior wall and lesser curvature...	3
Posterior wall and lesser curvature...	3
Posterior wall and greater curvature..	2
Both curvatures.....	2
Fundus.....	1

#### CLINICAL ASPECTS AND DIAGNOSIS

All authors agree that sarcomas of the stomach present no pathognomonic signs or symptoms. The condition is most frequently confused with ulcer or carcinoma of the stomach. There are no cases on record in which a clinical diagnosis of the tumor was established. In Westphalen's case a diagnosis of gastric sarcoma was made by examination of a piece of tissue accidentally obtained during gastric lavage. In Schlesinger's case a correct

diagnosis was established by examination of a portion of a metastatic growth in the rectum. That examination of supposed metastases is not, however, a reliable method for establishment of a diagnosis of a gastric tumor is proved in the case of Leube, where the histological examination of a skin tumor (interpreted to be a metastasis from a gastric tumor) proved to be sarcoma, while later the stomach was revealed to be the site of a carcinoma.

In the cases collected we note that progressive cachexia and anemia, abdominal or epigastric pain, nausea and vomiting, the palpation of an abdominal tumor and hemorrhage (bloody vomitus, or bloody stools) are among the more important symptoms which have served to direct attention to the condition; one or more of them appear in practically every case. These tumors do not tend to given clinical manifestations until late in their course, which accounts for the fact that in numbers of instances the patient is practically moribund before seeking medical advice, and a large inoperable tumor is found at an exploratory laparotomy, or the diagnosis is established at autopsy. We find an impressive proportion of cases in which the original growth in the stomach, although of considerable size, remained "silent" while the metastases produced signs and symptoms which occupied the clinical field. Instances of this sort are seen in the cases of Schlesinger, in which a secondary exudative pleurisy occupied attention, and that of Markiewitz (mentioned by Simon) in which the picture was dominated by large liver metastases which had undergone extensive cystic degeneration. Another instance is that of Cabot's case (15311) reported from the Massachusetts General Hospital, in which the patient's complaint was pain in left chest of four months' duration. Pus was removed from the chest and a diagnosis of subdiaphragmatic abscess was made. At operation an "abscess of spleen" was drained. It was only at autopsy that the true condition was discovered, a lympho-

sarcoma of the stomach and spleen, the abscess originating in the central portion of the tumor.

The signs and symptoms produced by sarcoma of the stomach are in general those of carcinomas. In most cases of gastric sarcoma which have come to clinical consideration, carcinoma has been the diagnosis rendered. In a series of 12 cases of lymphosarcomas reported by Broders and Mahle, the preoperative diagnosis were carcinoma, in 7 cases; ulcers of the stomach, 1 case; abdominal tumor, (probably inflammatory), 1 case; tumor of the pancreas, 1 case; pyloric obstruction, 1 case. Most authors have stated that clinically, gastric carcinoma and sarcoma cannot be differentiated. There are, however, the following features which are suggestive in attempting a differential diagnosis.

1. Hemorrhage, which though occasionally an outstanding feature (case of Dahs) and at times the direct cause of death (case of Roberts), is less frequent in this condition, and when present is usually a later symptom than in carcinoma. The reason for this is that sarcomas of the stomach are in the vast majority of instances derived from the submucosa and do not invade the mucosa until late.

2. Secretory disturbances and impaired motor functions with resulting symptoms of dyspepsia are less frequent, and are not so likely to be prominent in the case of gastric sarcoma than is the rule with gastric carcinoma. In this connection it may be remarked that while some writers report free hydrochloric acid absent, and the presence of lactic acid and the Boas-Oppler bacillus (Schlesinger, Gosset) in sarcomas of the stomach and seem to consider these as suggestive findings, it appears to be the consensus of opinion that they are of no diagnostic or differential value. Monti says that the hydrochloric acid does not disappear until late. Mathiew found hydrochloric acid absent in 11 out of 17 cases. Harlow Brooks found both lactic acid and hydrochloric acid in his

cases, and states that the simultaneous presence of both acids should at least lead to a serious consideration of the possibility of gastric sarcoma. Warner concludes that the absence or presence of free hydrochloric and lactic acid and the presence or absence of occult blood in the stools are very feeble points in the differential diagnosis.

3. Sarcoma does not produce stenosis as frequently, or at as early a stage as does carcinoma, although we do find cases (Klinkert, Schlesinger, Broders and Mahle) in which stenosis was produced and in which the outstanding symptoms were those of pyloric obstruction. Loeper observed 9 cases of stenosis in 120 cases of gastric sarcoma. The explanation for this comparative rarity of stenosis in gastric sarcomas appears to lie in the fact that carcinomas are more frequently located at the orifices, while sarcomas are more frequently along the curvatures. When stenosis is caused by a sarcoma it is more likely to be due to a massive infiltration of the stomach wall, rather than a narrowing of the pyloric orifice. Massive infiltration may lead to a dilatation of the stomach wall and gaping of the pylorus.

4. X-ray examination will usually furnish evidences of a gastric neoplasm but does not give information enabling a positive diagnosis of sarcoma. Douglas states that while the x-ray is the greatest aid in making a diagnosis of the presence of an operative lesion, "a positive diagnosis of sarcoma could not possibly be made by radiographic examination." Strauss, Black and Friedman and Hamburger state that due to the fact that the sarcomas infiltrate the muscularis and submucosa, it is many times impossible to demonstrate it by means of the fluoroscope or x-ray. Cutler and Smith state that "the x-ray alone gives a clue to the differential diagnosis since the sarcoma projects into the lumen rather than produces an ulcer, with the typical filling defect." Therstappen on the contrary, says that the roentgen picture cannot be said

to be really reliable or characteristic in sarcoma of the stomach.

5. Schindler believes that if one is familiar with the picture the diagnosis of diffuse lymphosarcoma of the stomach is possible with the gastroscope. The author states that in his case he did not make a correct diagnosis because he had never seen such a case before, but now he realizes that the condition "may present a characteristic picture in the gastroscope, which is entirely different from all other diseases of the stomach."

In spite of all these various views regarding differential diagnosis or even a diagnosis of sarcoma of the stomach, we have as previously noted, found no cases of a correct diagnosis being established by means other than an exploratory laparotomy or autopsy except in the previously mentioned case of Westphalen. In Schlesinger's case, which at subsequent operation proved to be a gastric sarcoma, the following preoperative diagnosis was made: "Pyloric obstruction, probably syphilis or sarcoma. Carcinoma not probable."

#### PROGNOSIS

In view of the malignant nature of the disease, prognosis is necessarily grave. Ruffin states that in his search of the literature the only report of a cure is that of Ruppert. The case was that of an old woman of seventy-eight on whom had been done a nearly complete gastrectomy fourteen years previously for a large lymphosarcoma which occupied almost the whole length of the stomach with involvement of the glands of the greater and lesser omentum and the region of the cardia. Finsterer reports a case of lymphosarcoma in a man twenty years of age which he operated nine years previously and who at the time of the report was in excellent health. Koettlitz states that while the condition is hopeless without treatment, due to the relative rareness of metastases, and the fact that some sarcomas are pedunculated, operation offers a certain chance of success. He then quotes Gosset's

statistics in which 39 cases of extragastric sarcoma showed 19 survivals after operation, while in 22 cases of the intragastric type, 8 recovered after resection. Warner considers that due to the fact that metastases are, as a rule, of later occurrence in the case of sarcoma of the stomach than of carcinoma of the same location, surgery is more promising in the former condition. He states that in certain instances where a tumor, if carcinoma, would hardly be worth the trial of removal, it might be attacked with some of success, if sarcoma, because of the improbability of metastases and lesser degree of malignancy. Scudder likewise shares this opinion and states that in the absence of metastases, a radical operation for sarcoma of the stomach appears to hold out better chances of cure than with a carcinoma of the same organ. Noordenbos makes the following statement: "The prospects of operation for gastric sarcoma are worse than in cancer of the stomach, the operative mortality being even larger, but when the patients have once tolerated their operation their prospects of survival are better. In absence of metastases the prognosis of radical operation is better in sarcoma, than in cancer of this organ."

The type of the sarcomatous growth is a consideration in offering a prognosis. Thus Brasch states that the average duration of untreated round cell types, (including lymphosarcoma), is about fifteen months, that of spindle-celled types twenty-four to thirty-two months and that of myosarcomas, three and one half years. Both Brasch and Warner state that the lymphosarcoma and round cell sarcomas are more apt to produce metastases and at an earlier date in the progress of the neoplasm than are any other non-epithelial tumors of the stomach and are also more apt to recur after removal. Warner attributes these facts as already noted to the small size of the cells and their ameboid properties. Both authors conclude that even the most prolific varieties, the lymphosarcomata and the leiomyosarcomata, show

less tendency to recur after excision than do carcinoma of the same region and for these reasons offer a better prognosis. Brasch states that this view is substantiated by the fact that the average duration of life after the onset of symptoms is longer than in cases of carcinoma, being frequently as much as three to four years. Kuchebski states that gastric sarcoma may be considered as less malignant than gastric carcinoma because of the fact that it metastasizes more rarely. He concludes, however, that this alters the prognosis very little as the patient dies as a rule in one or two years, just as in the case of carcinoma. He says that the only hope lies in a radical operation to guard against metastases and recurrences and only poor results can be expected from a gastroenterostomy, as the infiltrated walls do not easily anastomose.

The prognosis in a case of gastric sarcoma is undoubtedly influenced by the histological type and the form. All authorities agree that the pedunculated growth offers a much better prognosis than does the infiltrating variety. The apparent explanation for this is that a pedunculated growth offers a better chance for surgical extirpation and furthermore that they are most frequently of the spindle-cell type which is a relatively slow type of growth, tending to remain circumscribed and not readily metastasizing. On the contrary the diffuse form, which is almost always lymphosarcoma or round cell sarcoma, offers a worse prognosis than does carcinoma. Cavina says: "The prognosis does not seem to be very serious in extragastric spindle-cell sarcoma." His patient at the time of the report was well eight months after operation for removal of such a tumor. On the other hand, Gunsett and Oberling report the persistence of cure at the end of five years in a case of far advanced lymphosarcoma. It was considered inoperable, and an anterior enterostomy was done followed by several courses of x-ray therapy. They consider that these tumors are extremely radio-



sensitive and that such therapy will favor the prognosis.

Klinkert concludes that since the more malignant varieties, the round cell and lymphosarcomas, are comparatively more frequent in young individuals than the fibrosarcomas and myosarcomas which occur in later years, it would seem that the prognosis is worse in youth.

Haggard gives the following results in a series of 46 cases.

1. Died.....	20 cases
2. Recurrence.....	3 cases
3. Recovered and well for varying periods of from four to ten years.....	41 cases

In considering the prognosis, we may mention that gastric carcinomata have a greater tendency to perforate than have gastric carcinomata. Kolbe reports an interesting case of fibrosarcoma which developed silently until it perforated through adhesions into the abdominal wall, producing an abscess. About six months later this abscess gave rise to an acute peritonitis which caused death, and the diagnosis was established at autopsy.

Demel and Fritzsche also report cases which perforated. Gastric sarcoma have been said to perforate in 8 per cent of cases (Hesse quoted by Douglas). We would not be inclined from our studies to put the percentage nearly as high. Klaus writes regarding gastric sarcoma, "The prognosis of lymphosarcoma is bad. That of myosarcoma and fibrosarcoma offers a more favorable prognosis than does carcinoma."

#### SUMMARY AND CONCLUSIONS

1. Sarcoma of the stomach is a relatively rare form of neoplasm being most generally estimated as forming about 1 per cent of gastric malignancies and about 0.25 per cent of sarcomas in general.

2. They present no pathognomonic fea-

tures which would allow them to be diagnosed by clinical or laboratory tests.

3. Diagnosis is established only by histological examination of an excised portion of the tumor or of one of its metastases.

4. Clinically and by roentgen ray, gastric sarcomas are most frequently diagnosed as carcinoma or chronic ulcer, and it does not appear possible to make a differential diagnosis before operation.

5. While age is not of importance in the differential diagnosis, gastric sarcoma tends to occur in younger individuals than does gastric carcinoma, the average age for the onset of symptoms being 41.6 years for the former and 61.2 years for the latter. The average occurrence age for gastric lymphosarcoma is even lower than that of gastric sarcoma in general, being thirty-six years.

6. While the prognosis of gastric sarcoma is poor, it is frequently said to be better than that of carcinoma of the same region, due to the fact that it does not seem to metastasize so readily or at such an early stage in its development.

7. The essential etiology of these tumors is naturally unknown. Trauma, preexisting neoplasms of a benign nature and chronic ulcers have been discussed as possible etiological factors.

8. Lymphosarcomas of the stomach are usually of the infiltrating variety, occur in younger individuals than do the spindle-celled type of tumors which are more frequently pedunculated. These latter offer a much better prognosis than do the former due to the fact that they metastasize more slowly and are more readily extirpated surgically.

9. Three hundred and thirty-five cases of sarcoma of the stomach, including the four herein reported, are recorded in medical literature through the year 1929. [For Bibliography see Author's reprints.]

# EVALUATION OF THE X-RAY EXAMINATION IN DUODENAL ULCER\*

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**E**VEN the radiological consideration of duodenal ulcer should take into account the fact that this condition is a disease and not a lesion. The etiology is evidently not at all clearly understood. The focal infection theory sponsored by Rosenow has many adherents but the evidence for it does not seem at all conclusive to perhaps the majority of clinicians. It has been impossible to produce at all uniformly in laboratory animals anything closely resembling the typical peptic ulcer which occurs in man either by inoculation of specific strains of bacteria, by traumatism, by maintenance of increased acidity or by any other means. It was Virchow's idea that ulcer was caused by thrombi or emboli and this theory still has supporters among pathologists. Others consider the initial lesion to lie in the autonomic nervous system and link the condition with the supposed functional disturbance known as vagotonia, which is presumed by this school to precede the actual breaking down of the mucous membrane resulting in ulcer. Heller modifies this view by assuming the occurrence of toxic or infectious injury to the vagus, causing spasm of the intrinsic musculature followed by ulceration.

Local vasoneurotic disturbances involving the so-called ulcer bearing area and resulting in a spotted hyperemia of the mucosa with dilatation of the capillaries apparently accompanies many peptic ulcers and is to a rather definite degree characteristic of the condition which precedes ulcer or makes it possible.

The failure after many years of intensive investigation to discover any constant, etiological factor, plus the well-known tendency of ulcer to recur after prolonged absence of symptoms and after apparent medical or surgical cure, leads most

clinicians of long experience to the belief that there is an underlying ulcer diathesis, the nature of which is as yet quite unknown. Almost universally the presence of hyperacidity has been considered not only a diagnostic point of great value but the chief factor in preventing the ulcer from healing. Yet even Sippy, the strongest and most logical advocate of this theory, admitted that in every series of ulcer cases there was a certain fairly large number of normal acidities and a few subacidities or even complete achlorhydrias. It is very difficult to explain the persistence of ulcer in these cases, if one adheres to the acid theory, and the occurrence of normal or subacidities in, according to some authors, as high as 30 per cent of ulcer cases makes gastric analysis of much less value from the diagnostic standpoint. Its importance is further lessened by the fact that there are a few, persistent instances of hyperchlorhydria which fail to develop ulcer over even a rather long period.

The presence of occult or visible blood in the stomach contents after aspiration, or in the stool after the patient has been on a meat free diet for several days is of some value in the diagnosis of ulcer, provided a number of confusing factors can be excluded. This finding is, for instance, quite the rule in malignancy of the stomach; apparently it occurs occasionally from traumatism at the time of intubation, and certainly it frequently accompanies carcinoma of the biliary tract. It is, of course, of value only if positive, since not all ulcers bleed and those which do, do so only occasionally. It seems evident, then, that the chemical and microscopic investigation of stomach contents and stool, while still undoubtedly deserving an important place in the routine

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of diagnosis, are not in themselves dependable or sufficient.

The value of history has been stressed

food-taking in its times of maximum severity but by no means as definitely so as the ordinary type of chemical discom-

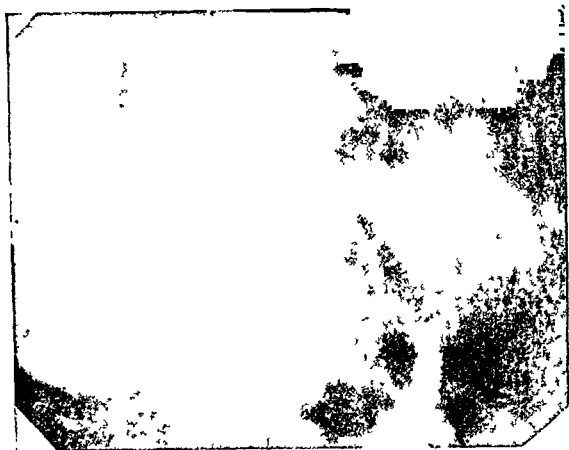


FIG. 1. Typical spastic bulb deformity of active duodenal ulcer with marked hyperperistalsis. Failure to outline pylorus completely due to posture and not to disease.

by all clinicians and perhaps especially by Sippy, and cannot be denied. Provided the clinician is sufficiently familiar with the symptoms of the disorder, he can in the typical case at any stage hazard a fairly accurate conclusion as to the location and character of the lesion and the extent of complications, if any, from the history alone. The clinician who knows ulcer well enough to do this, however, will perhaps be the first to agree that other conditions presenting no organic lesion in the stomach or duodenum can, under exceptional circumstances, simulate very closely and to a very confusing extent the picture of duodenal ulcer.

It is apparently the rule that duodenal ulcer does not come under exhaustive clinical investigation until several years after the inception of the symptoms and even if they were perfectly typical during the first few months of the disease, they are quite apt to diverge widely from the textbook picture in later years. Perhaps everyone who has seen a considerable number of ulcer cases will recall instances in which the symptom complained of most bitterly was a pain in the upper lumbar or lower dorsal region somewhat related to

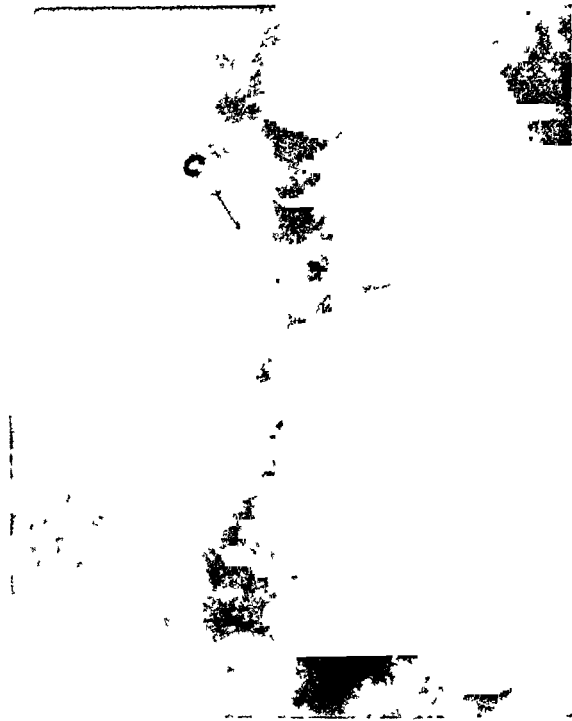


FIG. 2. Typical marked bulb deformity from ulcer. c indicates crater.

fort. I have on two or three occasions been called upon to examine the spine in an effort to trace the cause of this type of pain when it proved later to have been due to duodenal ulcer. Oddly enough, the back pains are temporarily relieved by alkalis just as is the usual epigastric discomfort.

Ulcers are apt to be accompanied by a greater or less degree of spastic disturbance of the colon which probably accounts for the fact that in many instances the most annoying symptoms in established duodenal ulcer are referable to the colon rather than to the stomach or duodenum. Distressing accumulation of intestinal gas is very frequently part of this picture and alternating periods of constipation and diarrhea quite apart from effects of diet and medication are sometimes more conspicuous, so far as the patient's voluntary comment is concerned, than the chemical discomfort. Occasional periods of persist-

ent soreness and tenderness in the epigastrium lasting for days or perhaps for weeks and not relieved by food or alkalies are

presents a fairly typical ulcer syndrome is a case of duodenal ulcer, how can the condition be recognized with any satis-

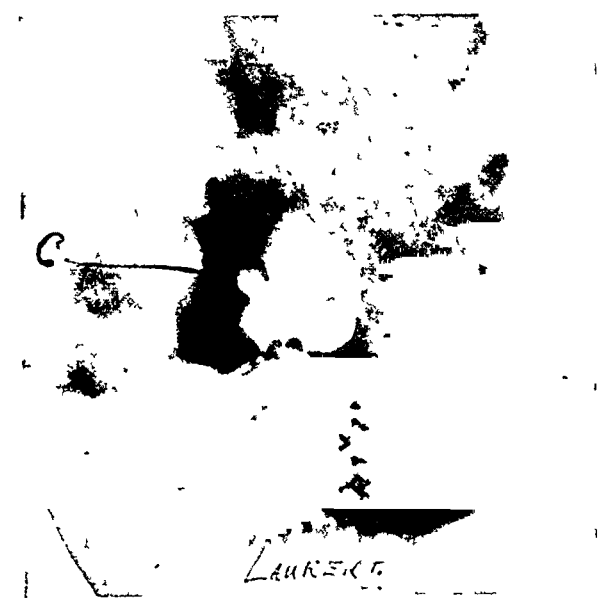


FIG. 3. Typical bulb deformity from ulcer. c indicates crater. Note spastic incisura on both borders just above and left of crater.

not at all uncommon in established ulcer and are also, of course, the usual preliminaries to slow perforation. These attacks of soreness are presumably traceable to perigastritis or periduodenitis but they may recur from time to time for years without evidence of extensive inflammatory reaction about the pylorus or duodenum being visible at operation and without being followed by perforation.

Duodenitis is probably very frequently a cause of atypical symptoms and apparently there is occasionally a duodenitis with a rather characteristic intolerance of the duodenum to barium which often precedes the actual establishment of ulcer or at least which precedes any deformity which can be visualized. It has recently been pointed out that the institution of the ulcer regimen at this stage, rigidly adhered to for three or four weeks, may possibly prevent the formation of ulcer.

It is evident then that it is not always possible to diagnose duodenal ulcer either from the history or from the laboratory findings and since not every case which

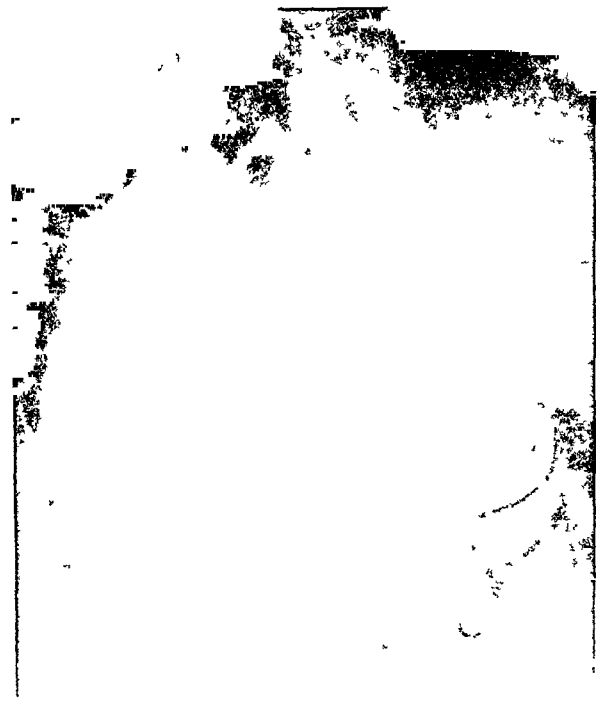


FIG. 4. Bulb deformity from adhesions. No lesion in duodenum.

factory degree of certainty? The answer is the same as would be given with regard to an ulcer on the leg: by looking at it. There is, practically speaking, no other lesion than duodenal ulcer which will produce a typical deformity of the duodenal bulb and there is no practical possibility of an ulcerated duodenal bulb presenting a normal x-ray appearance. Therefore, the x-ray diagnosis of duodenal ulcers should be and is, in the hands of competent and experienced gastrointestinal radiologists, as nearly accurate as any diagnostic measure.

The first part of the duodenum, referred to by radiologists as the cap or bulb, is the first inch or inch and a half of the duodenum distal to the pyloric ring and it acquires these appellations from its shape, as visualized when completely filled with barium, under the fluoroscopic screen. It is the site of practically all duodenal ulcers. It is almost never the

site of malignancy and it is with extreme rarity that any other intrinsic lesion except ulcer is found there. The bulb may be

of the deformity is that due to spasm and this is, to a considerable degree, a measure of the activity of the ulcer.



FIG. 5. Marked dilatation of first part of duodenum due to ulcer at distal end of bulb with obstruction at that point.

visualized with greater or less difficulty according to the habitus of the individual and according to the rapidity with which it fills and empties. Given, however, a sufficient amount of patience and ingenuity, it can be visualized in a filled state on the fluoroscopic screen almost without exception in all individuals and can, as a rule, though not always, satisfactorily be shown on films.

It remains then, so far as the diagnosis of this particular lesion is concerned, for the radiologist to visualize the bulb in a filled state for a sufficient long period and in a sufficient number of projections to satisfy himself that it really is, or is not, of normal contour.

If it is normal in outline (and the normal outline varies somewhat with the shape of the stomach) certainly it is not ulcerated. If it is deformed, the deformity must be due either to ulcer with spasm or to adhesions; and the latter type of deformity can, as a rule, be readily distinguished from that of the ulcer.

Oftentimes the most conspicuous part

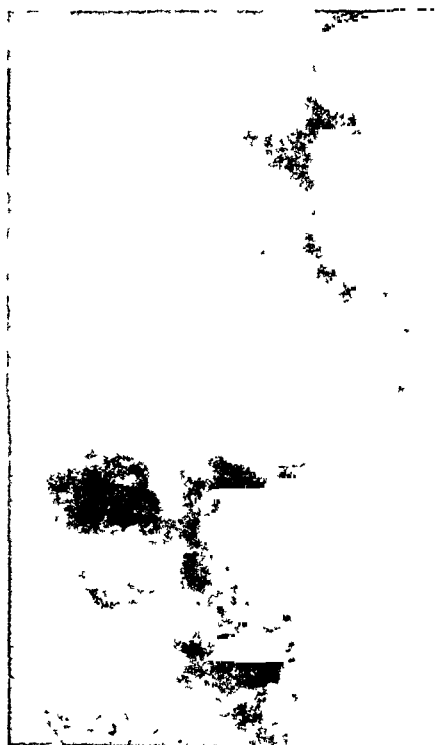


FIG. 6. Small, contracted, deformed bulb with early obstruction.

Thus a healed ulcer, if of any size, is very apt to cause a persistent deformity of the bulb throughout the life of the individual, but is no longer accompanied by spasm. It should then be possible to affirm not only the presence of ulcer but its size, its location and the extent to which it is accompanied by spasm. These data are of equal importance with the demonstration of its existence, in forming a basis for prognosis or treatment.

It occasionally happens that a competent radiologist makes a diagnosis of duodenal ulcer on such excellent grounds that he considers it unassailable and yet, when the surgeon opens the abdomen shortly after, he is unable to find any evidence of the lesion. These occurrences are very embarrassing to all concerned and naturally the blame is ultimately passed to the radiologist where, indeed it would seem, on the face of the matter

to belong. When Carman at the Mayo Clinic was engaged several years ago in establishing a direct diagnosis of duodenal ulcer by visualization of the lesion, this sequence occurred several times and for some months he accepted the burden of these apparent errors with decreasing cheerfulness and with perhaps some growing doubts as to the accuracy of his own conclusions. Then he began to insist on an investigation of the inside of the duodenum instead of accepting the surgeon's negative conclusions based on lack of characteristic stippling of the peritoneum and lack of induration, and this led to the true explanation, namely: that there existed in these instances very superficial mucous ulcers which were, however, surrounded by an inflammatory zone of sufficient extent to cause the characteristic spasm. These cases were true duodenal ulcers but they were, histologically speaking, very early and had not yet produced the characteristic external changes. Since the spasm which is so prominent to the vision of the radiologist is entirely relaxed by the anesthesia, these duodenal bulbs looked perfectly normal and since no induration was present, they felt normal: yet the ulcer was there and visible enough when the mucosa was exposed. I have had the experience of having this type of lesion chalked up against me as an error in diagnosis only to reexamine the patient a few months later and find a well-established, typical ulcer which at a second operation was equally evident to the surgeon.

A case which recently came under observation is decidedly in point.

The patient, a physician himself interested in gastroenterology, had had for approximately ten years very definite and typical symptoms of duodenal ulcer relieved from time to time by the ordinary routine medical treatment. After several months of relative freedom from symptoms a massive hemorrhage suddenly occurred and as it could not be controlled by the usual medical measures, surgical interference was resorted to. Approximately four

years before operation, this physician had been examined by one of the most prominent radiologists in the country and a definite



FIG. 7. Contracted, deformed bulb with fairly high-grade obstruction.

and typical duodenal ulcer had been located on the lesser curvature surface of the bulb near the base. In view of this fact the patient explained to the surgeon that the bleeding lesion would probably be found at this point and would undoubtedly be an old, calloused ulcer of considerable extent. When the duodenum was examined through the incision the surgeon at first had the impression that no ulcer was present. There was no scar. There was no callus or thickening of the wall. There was not even any stippling of the peritoneal surface. The duodenum was then opened and with some difficulty the bleeding lesion was located. It was found to be a very shallow, superficial affair at the distal end of the bulb. There was not even any infiltration of the wall and in fact everything in its appearance pointed to its being an extremely recent affair. The only possible conclusion was that the ulcer formerly observed and presumably accountable for years of symptoms had healed leaving no palpable scar and that the hemorrhagic lesion was a recent and separate one.

This case brings out in an unusually clear way several points of considerable interest. It supports the hypothesis of an underlying predisposition to ulcer showing

that the original lesion may heal even without scar formation and another form at some later date. It may offer an explanation of the often-quoted, somewhat cynical remark that after an ulcer has been cured a certain number of times by medical measures it should be subjected to surgical intervention. Probably ulcers are often actually cured by medical handling and the recurrence of symptoms is due not to a reactivation of the old ulcer, but to the formation of a new one. Hemorrhage from a duodenal ulcer is, of course, to be classed as an accident more than as a symptom of the disease. In other words, it is entirely dependent on the location of the ulcer and the accident of its eroding a vessel, large or small, an occurrence which may not take place with an extremely extensive, old ulcer but which, on the other hand, can and often does occur with a very recent and very superficial lesion. Examination of patients with an undoubted clinical history of hemorrhage from a duodenal ulcer within a reasonably short time after the occurrence of the hemorrhage often fails to disclose any extensive or characteristic deformity.

A diagnosis is often made by the presence of the deformity produced by spasm when the lesion itself is very small and may be difficult or impossible to visualize. Spasm in the first part of the duodenum is believed to be caused by reflex irritation from a hyperemic inflammatory zone about the ulcer through a short arc intrinsic in the duodenum itself. Hence, it is not relaxed by the administration of even large doses of belladonna while, on the other hand, it is completely relaxed by general anesthesia.

For this reason, antispasmodics are of little value in the re-examination of suspected duodenal ulcer cases in which the first examination has been for some reason unsatisfactory or inconclusive. They are of considerable value in the reexamination of cases of suspected gastric ulcer.

It was formerly the rule that approxi-

mately one-third of the cases diagnosed by x-ray were identified only by the so-called indirect signs consisting of enlarged stomach, hypertonus and hyperperistalsis and a considerable four and a half hour or six hour residue coupled with inability to visualize a normal duodenal bulb. In more recent years this has been considered a somewhat unsatisfactory type of diagnosis and the feeling has obtained that with sufficient care the bulb or what remains of it should be capable of visualization.

The amount of residue present in the stomach after the normal emptying period has passed may vary considerably from time to time even in the presence of rather high-grade organic obstruction. Thus it is not infrequent to see a patient with a 50 per cent four and a half hour residue progress to a normal emptying time after a few weeks on a carefully supervised ulcer regimen. This does not, of course, mean that the diet (and the alkalis, if these are given) have brought about the absorption of any organic obstruction due to scar tissue but rather that most of the obstruction was due to an inflammatory process which has subsided under the measures adopted. These are probably early cases of true organic obstruction which will, in the absence of surgical relief, go on to high-grade stenosis.

It is essential for the radiologist to bear in mind certain rare developments in a course of duodenal ulceration which occasionally produce confusing and atypical x-ray appearances. One of these, illustrated in Figure 5 is stenosis of the duodenum at the junction of the first and second portions, just caudad to the bulb with consequent dilatation or sacculation of the bulb. This is to be distinguished from duodenal diverticulum which it might suggest. It should be recalled that through subacute perforation a spontaneous anastomosis may form between the bulb and the distal duodenum. This is evidently an extremely rare occurrence and has never come under the writer's observation although the comparable instance of spon-

taneous anastomosis between the ulcerated stomach and the duodenum, jejunum or colon is observed from time to time with equal potentialities for confusing the diagnosis unless these possibilities be kept in mind.

Finally, the radiologist is not infrequently called upon to reexamine known cases of duodenal ulceration after treatment or operation with a view to determining the activity of the lesion. Such examinations are probably considerably less satisfactory in the case of duodenal ulcers than in gastric ulceration. If a

definite ulcer crater has been observed prior to operation or treatment and cannot be demonstrated on reexamination, it is perhaps reasonably safe to assume that the ulcer has healed. One must not expect after definite ulceration has once occurred, whether or not there has been operative interference, to observe a smooth bulb of normal contour. Some conclusions may be drawn from the presence or absence of spasm. Delayed motility, if present, can, of course, be determined. Reports of such examinations should, however, be somewhat guarded.





# CARCINOID TUMORS OF THE SMALL INTESTINES\*

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CANCER is notably infrequent in the small intestine. From 0.1 to 0.5 per cent of all malignant tumors are situated in this region. This infrequency is singular when we consider the relatively large surface area of intestinal mucosa which is exposed to possible irritation. Carcinoma of the small intestine occurs in subjects of comparatively early life; the average age is usually about forty years although many cases occur in the decade of twenty to thirty. From three-fifths to two-thirds of all the subjects are males. The common histological type of cancer in this location is the ordinary adenocarcinoma. The carcinoid tumors are rare and constitute an interesting clinical and pathological study.

Carcinoid tumors are quite frequent in the appendix, particularly in instances of so-called obliterative appendicitis. The ileum is next in frequency as the site of their occurrence; other infrequent locations are the duodenum, jejunum, colon, rectum and Meckel's diverticulum (Stewart and Taylor). These tumors are frequently multicentric in origin. They are button-like, circumscribed but not encapsulated tumors invariably situated on the anti-mesenteric side of the bowel. They may lead to a slight degree of stenosis and occasionally are the cause of intussusception. They may exist for a long time without ulceration. The tumor cuts without grating; the cut surface is waxy, firm and yellowish white.

## THEORIES OF HISTOGENESIS

We shall give briefly the various theories concerning the histogenesis of this peculiar

tumor, naming these theories in the chronological order of their publication.

(a) *Lubarsch* in 1888 employed serial sectioning of these tumors and found that certain cells in the apices of Lieberkuehn's crypts broke through the basement membranes and formed independent cell groups. Lubarsch observed the growth of these cell masses into lymphatic vessels and labeled this primary tumor "carcinoma cylindromatosum." He differentiated these tumors from other adenocarcinomas occurring in the alimentary tract by certain peculiar features, namely, multicentric origin, absence of true glandular structure, disinclination to metastasize and cellular dissimilarity.

(b) *Krompecher* in 1903 designated this tumor as a "basilome" and declared its origin to be from the cylindrical cells of the intestine. Later in 1919 *Krompecher* modified his theory and asserted that these tumors were identical with the basal cell carcinomas of the skin. He observed three types, solid, adenoid and cylindromatous. At this time he considered two possible origins:

1. From the cylindrical cells of the intestine.

2. From the basal cells of the crypts of Lieberkuehn.

(c) *Schmidt* in 1905 described certain basal cells occurring in the intestinal mucosa which he considered to be the same as the cells described by *Kultchitzky* in 1897.

(d) *Oberndorfer* in 1907 reported six instances of these tumors and first proposed the name "carcinoid."

(e) *Trappe* in 1907 expounded the

\* Submitted for publication March 5, 1930.

theory that carcinoid tumors and adenomyomas of the small intestine had a common origin from pancreatic rests. The

lipoids, vacuoles and silver-positive granules in the cytoplasm. On the basis of this observation he emphasized the resem-



FIG. 1. Multiple carcinoid tumors of ileum. Mucosal surface uppermost to demonstrate gross characteristics of these neoplasms.

carcinoid tumor was less differentiated than the adenomyomas and therefore was assumed to have a greater capacity for growth.

(f) *Burkhard* in 1909 agreed with *Krompecher* on the similarity of these tumors with basal cell cancers of the skin. His several reasons for this assumption were based on certain features of the carcinoid tumor, namely, its failure to differentiate, its low degree of malignancy, its tendency not to metastasize and its seeming continuity with the intestinal epithelium. He decried the possibility of an origin from pancreatic rests because of his inability to detect ducts or pancreatic acini in the tumor.

(g) *Toenniessen* in 1910 considered these tumors as originating in submucous rests possibly of *Langerhans'* islands. He suggested a relationship to the endocrine system.

(h) *Huebschmann* in 1910 also suggested the possibility that these carcinoid tumors might evolve from the *Schmidt* chromaffin cells lying in *Lieberkuehn's* crypts.

(i) *Masson* in 1910 made a thorough study of these peculiar cells and observed

blance of these cells to the medullary cells of the adrenal gland and to other cells of the chromaffin endocrine system. In 1912 and later he elaborated his theory to prove conclusively for the first time the exact nature and origin of these carcinoid tumors. We will quote this theory in detail.

Certain intestinal cells (of *Kulchitzky*) bud out and migrate into the nerves. Here they become argentaffine. They differentiate into various forms, cylindrical cells grouped in rosettes or vesicles, cells of ganglion type, of Schwannian type, neurocrine cells. The nerves containing them grow and become neuromata, or disappear if the cells themselves disappear. Carcinoids result from the autonomous proliferation of the isolated neurocrine cells present in the neuromata . . . Either the nerve plexus is of sympathetic origin and proliferates under the irritating or secretory influence of the cells which have emigrated from the intestinal epithelium . . . or the periglandular plexus consists of a mixture of fibers, some sympathetic, others belonging to another nervous system, autonomous and autochthonous, of entodermic origin.

In conclusion, *Masson* considers the possibility of a neuro-entodermic placode

of which the cells of Kulchitzky might be the sole manifestation in normal conditions. "Schleimhaut" nevi, or mucous membrane nevi.

(n) Engel in 1923 labeled these tumors

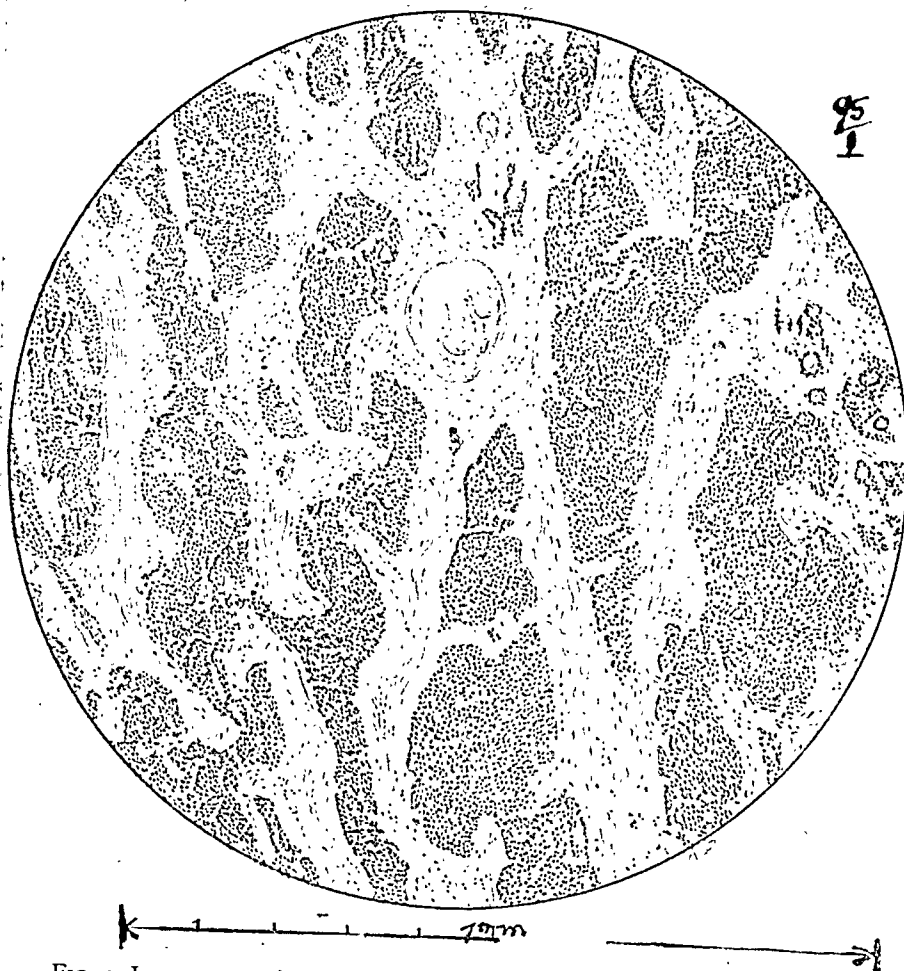


FIG. 2. Low power microscopical view of deep portion of carcinoid tumor.

(j) Luce in 1912 termed these tumors basal cell carcinomas of the mucous membrane.

(k) Saltykow in 1912 studied 7 cases and came to the conclusion that these tumors originated from pancreatic rests of Langerhans' islands. He defended his argument by calling attention to the fact that it was possible for the Langerhans cells to be included in the intestine because they differentiate earlier in the embryo than does intestinal muscle.

(l) Hasegawa in 1923 agreed in general with Masson's theory as to the origin of these tumors from Schmidt's cells or the cells of Kulchitzky.

(m) Aschoff in 1923 called these tumors

"choristoblastomas" and admitted their origin in embryonic rests.

An analysis of the numerous theories of histogenesis given here permits us to classify them in three main groups:

1. A type of basal cell cancer (Krompecker, Burkhard) or nevus (Aschoff) of mucous membrane.

2. A tumor originating in embryonal rests particularly of pancreatic islands. This hypothesis corresponds to the Cohnheim-Durante theory of tumor origin and is accepted by Saltykow, Engel, Trappe and Toeniessen.

3. A tumor originating from the cells of the intestinal epithelium: Lubarsch, Hueb-

schmann, Masson and Hasegawa. Masson's conception of nerve relationship is the most logical explanation to-date.

size, rich in chromatin, placed in the center of the cells, having a capacity to stain deeply and containing prominent

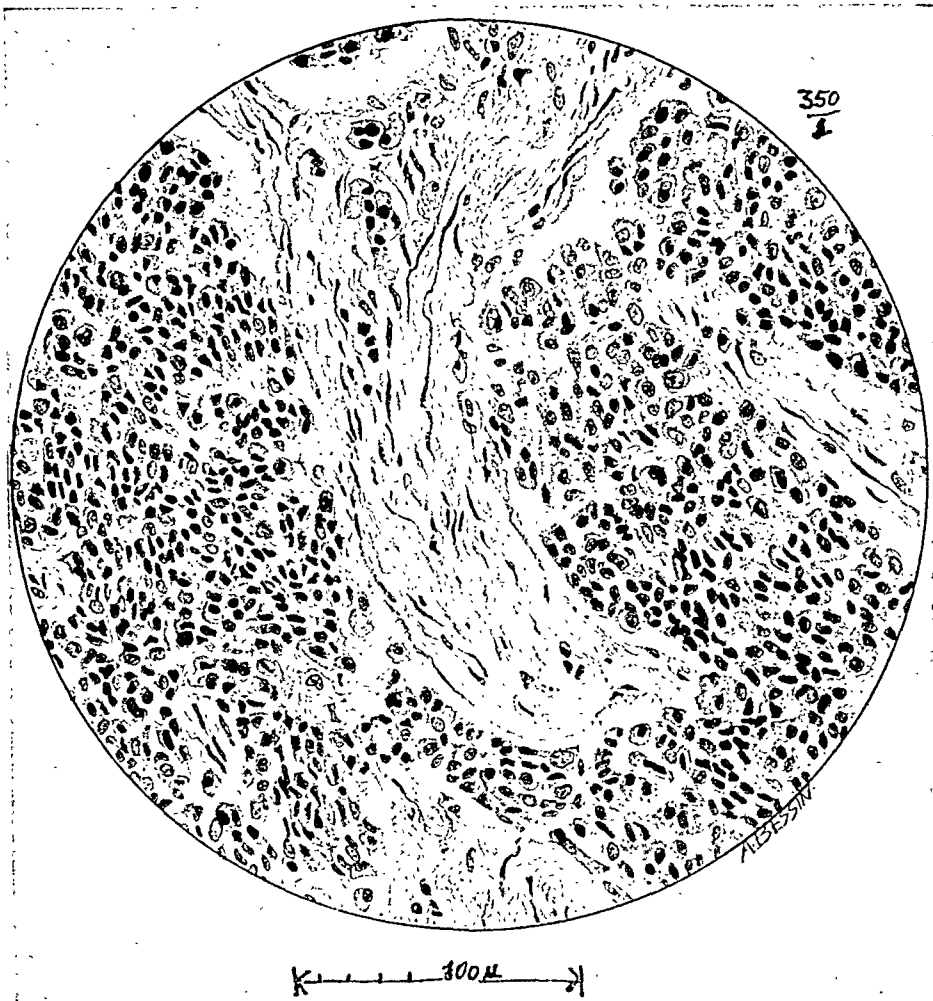


FIG. 3. High power microscopical view of same field as in Fig. 2. To show solid cords of undifferentiated cells and character of nuclei. Definite morphological resemblance to basal cell carcinoma.

#### MICROSCOPICAL APPEARANCE

The tumor cells are grouped in nests composed of solid cords in some of which a pseudoglandular arrangement is seen. This gland-like arrangement is more common in the benign carcinoid tumors and is found in the superficial portion of the tumor near the intestinal mucosa, rather than in the depth of the intestine where the cords of cells are usually solid. There are no true alveoli. The major portion of the tumor is composed of undifferentiated cell masses. The nuclei are large, oval to round and regular in shape, uniform in

nucleoli. The cytoplasm stains indifferently, is moderate in amount and occasionally contains reddish brown granules when stained by the ordinary methods.

Hasegawa demonstrated intracellular lipoids in these cells on frozen section, a finding said to distinguish these tumor cells from the cells of true adenocarcinoma.

There are certain granules in the cytoplasm of these cells which have an affinity for silver. These so-called argentaffine granules can be shown by proper staining methods in the Schmidt or Kulchitzky cells *in situ* in the crypts of Lieberkuehn

as well as in the carcinoid tumors. In fact, this staining reaction has been of great importance in studying the histo-

thin-walled blood vessels are found within the tumor cell nests; this phenomenon of angiotropism is characteristic of carcinoid

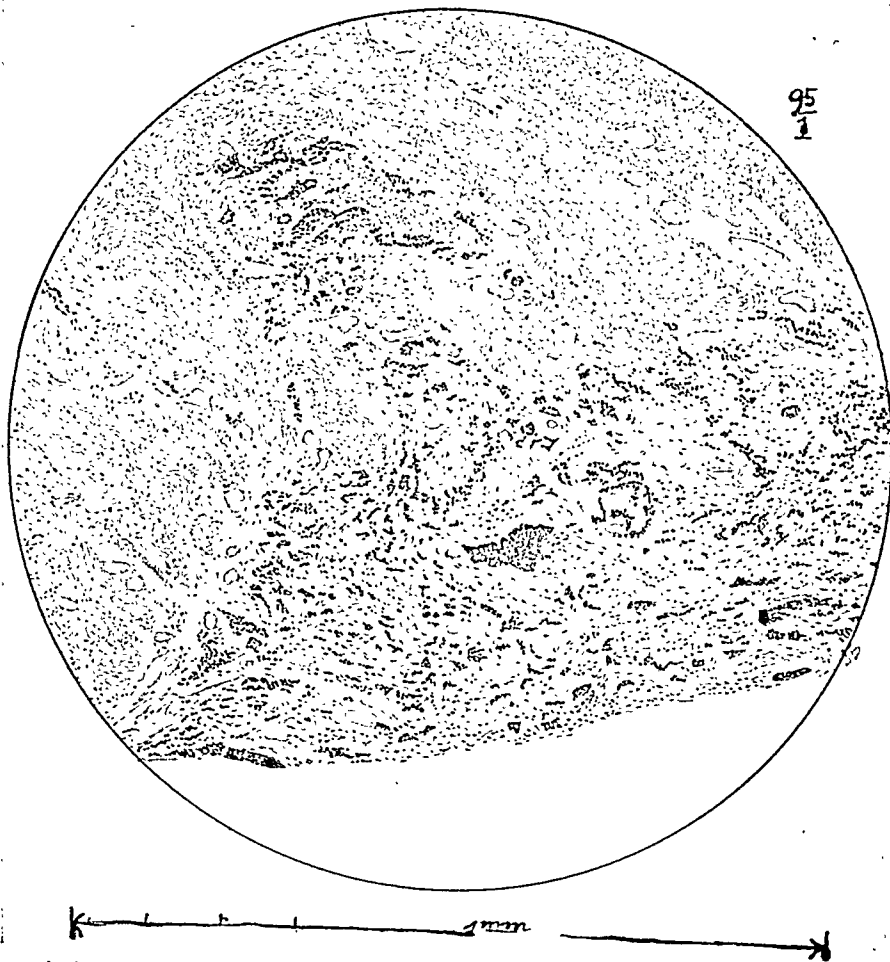


FIG. 4. Microscopical view of serosal surface of ileum. To show infiltration of carcinoid cells through muscular coat.

genesis of these carcinoid tumors. When the tumor undergoes malignant degeneration it loses a proportionately large amount of these argentaffine granules. Therefore some of the malignant carcinoid tumors do not react positively to silver stains. For instance, in 2 of Hasegawa's cases in which malignant changes were associated with the carcinoid tumor, no argentaffine cells could be found. The same condition obtained in the tumor reported herein.

Carcinoid tumors which have metastasized have larger cells as a rule than the ordinary benign carcinoid tumors. Mitoses are never abundant. A number of

tumors and does not occur in true carcinomas. There is no true supporting stroma within the cell nests, but surrounding these groups of cells are fibrillar hyaline tissue and smooth muscle.

The muscularis mucosae is always present but is usually fragmented so that the cell masses are surrounded by many thin strands of smooth muscle. There is a variable degree of invasion of the muscular coats of the small intestine. This is another peculiarity of this neoplasm in that it is an infiltrating benign tumor. The serosa is rarely involved but occasionally is infiltrated as noted in the accompanying

case report (Fig. 4). The mucosa overlying the tumor is usually intact.

#### METASTASES

Stewart and Taylor were able to find only 18 cases of carcinoid tumors with metastasis recorded in the literature prior to 1926. Dukes and Lockhart-Mummery added another case. Ransom and Notthaft have also reported instances where carcinoid tumors of the ileum gave rise to metastases. There have been numerous instances reported where the carcinoid tumor cells have been found in the lumens of the veins. The direct extension of cords of tumor cells onto the serosa and into the mesenteric fat should not be construed as an indication of malignancy. When metastases do occur they are found most frequently in the regional lymph nodes, peritoneum, liver and pleura. Because of the rarity of metastasizing carcinoid tumors we feel justified in reporting our unusual case.

#### PROGNOSIS AND TREATMENT

The growth of carcinoid tumors is usually very slow. The majority of these tumors remain benign and harmless. Local excision is usually sufficient as they have no tendency to recur. Their growth is usually asymptomatic and the first indication of their presence may be intussusception. If metastasis has occurred to the regional lymph nodes, these should be removed at the time of the excision of the primary tumor.

#### CASE REPORT

J. S., a male negro, aged seventy-three years, was admitted to the Hillman Hospital, Birmingham, in a semicomatose state. No past or present history was obtained. The clinical diagnosis was cardiovascular-renal disease. The patient died in a few hours after admission.

At the necropsy, there were bilateral pleural adhesions and chronic pulmonary tuberculosis. There was generalized arteriosclerosis with

very large ulcerated atheromatous plaques in the aortic arch. The atria were dilated and there was fatty infiltration of the heart. The kidneys were of the small red type which microscopically showed evidence of vascular nephropathy (arteriocardillary fibrosis).

The alimentary tract was normal except for the presence of 2 small sessile nodules in the lower ileum. The lowermost of these nodules was 9 in. distant from the ileocecal valve. These nodular tumors were situated 5 in. apart and there was no indication of a common origin. They projected into the lumen and caused a slight degree of stenosis. One of these tumors measured  $1.5 \times 2$  cm., the other measured  $1 \times 1$  cm. The mucosa was intact and surrounded the tumor. On cut section the tumors were of the same consistency throughout. They were grayish-white and waxy, firm yet elastic.

Microscopically, the intestinal villi were largely replaced with cords and nests of carcinoid tumor cells. In the superficial part of these tumors the cell nests were large and the cells had a tendency to form glands. But in the deeper portions of the tumors the nests and cords were smaller, there was no pseudoglandular formation and many of the cells were infiltrating the muscle layers in thin strands. The muscularis mucosae and connective tissue formed a stroma for the cell cords. Many small blood vessels were seen in the cell nests; they had no particular relation to any part of the cell nests, but were situated at irregular locations. The nuclei were large, pale and ovoid. The peritoneum was infiltrated with small strands of tumor cells.

Several enlarged lymph glands were found in the adjoining mesentery. The largest of these mesenteric lymph glands contained a large deposit of carcinoid tumor cells, which in some areas had entirely replaced the lymphoid structure. The diagnosis was confirmed by Dr. James Ewing.

#### SUMMARY

The various theories of the histogenesis of carcinoid tumors are reviewed. A case report is given of an unusual instance of multiple carcinoid tumors of the ileum with metastasis to a mesenteric lymph gland. [For References see Author's reprints.]

# ROUTE OF METASTASIS IN CANCER OF THE BREAST\*

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**E**NLARGEMENT of the axillary or subclavicular lymph glands is generally considered the first sign of metastasis in carcinoma of the breast. In over 60 per cent of cases the axillary nodes can be felt to be enlarged when the patient presents herself. In other cases, the glands are not enlarged but are found to be malignant when removed at operation.

The case I am reporting is of interest because it showed malignant involvement in a single group of glands, one that is frequently overlooked in surgical exploration. I am referring to the glands lying along the third digitation of the serratus magnus muscle.

Another interesting feature was the peculiar type of tumor, which resembled a multilocular proliferating cyst of the ovary. However, the epithelial cells showed unquestionable evidence of carcinomatous change.

With reference to the anatomical routes by which cancer spreads from the breast, the most frequent form of lymphatic dissemination is by way of the lymphatic vessels that empty into the lymph nodes overlying the digitation of the serratus magnus arising from the third rib. There are 2 anatomical reasons for the predilection of cancer metastasis from the breast for the serratus glands: (1) This region includes the great majority of mammary lymphatics; (2) it drains the lymph from the part of the breast which is most frequently involved in malignant disease, namely, the upper and outer quadrant.

The subclavicular glands and those in the axilla are only secondarily involved in cancer of the breast. Yet, as a general rule, they receive most attention in searching for metastasis and also in the general

eradication of lymphatic tissue to provide against recurrence.

The anatomical facts and the findings in the case I am reporting support the belief that the glands lying along the third digitation of the serratus magnus are the first to be involved in malignancy of the breast. As a clinical deduction, especial care should be taken to remove these glands during the radical operation. Because of their deep situation below or along the lower border of the pectoralis minor, they are undoubtedly often overlooked and provide a source for recurrence.

## CASE REPORT

Y. S., a married white woman, aged sixty-two years, was admitted to the Sydenham Hospital on November 19th, 1928, complaining of a lump in the left breast. It was first observed three months previously, since which time it had grown rapidly. The mass was located in the upper and outer section of the breast. There was no enlargement of the axillary glands or supraclavicular tension.

Because the rapid growth of the mass, which was slightly adherent to the skin, strongly suggested malignancy, operation was performed. A triple incision was made: (1) in the axillary region along the upper hair line, (2) along the lateral edge of the pectoralis major muscle and continued so as to surround elliptically the skin area of the breast with the tumor in its center, and (3) continued over the xyphoid process of the sternum.

The upper flap was reflected first and dissected upward as far as the lower portion of the clavicle and inward as far as the middle of the sternum. The lower flap was dissected downward as far as the anterior sheath of the left rectus muscle (epigastric triangle) and the fascia of the external oblique muscle; laterally, to the serratus magnus and latissimus dorsi. The sternal portion of the pectoralis

\* Submitted for publication February 14, 1930.

major was severed at its insertion to the humerus and again at its origin from the ribs and sternum. The whole mass was turned

and outer quadrant about 2 in. from the nipple, was found in the excised breast. It was not attached to the underlying tissue. On section,

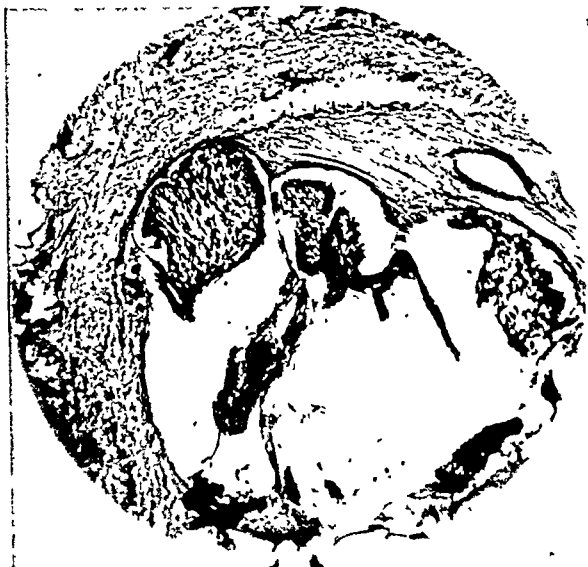


FIG. 1.

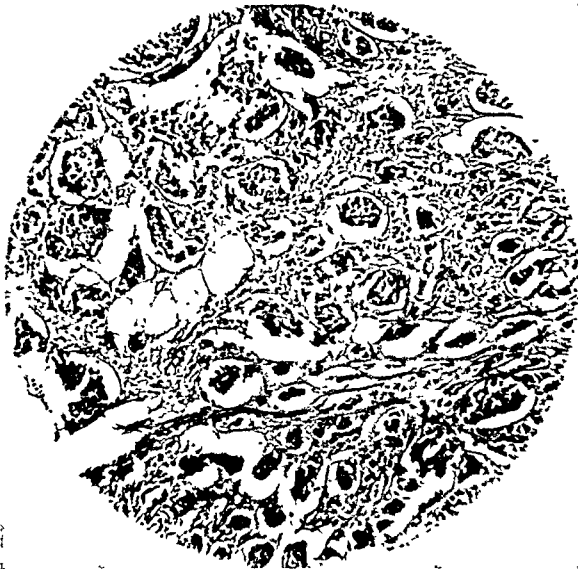


FIG. 2.

outward and removed in one piece together with the fat and glands found in the axillary fossa. As careful examination showed no enlarged glands in the infraclavicular region, the pectoralis minor was not removed.

The operation was conducted with a minimum of hemorrhage. Bleeding of the larger vessels was arrested by hemostats; from the smaller ones, by hot compresses. Before the skin was closed, a soft rubber tube of the thickness of the little finger was introduced through a stab opening in the posterior flap immediately in front of the latissimus dorsi and placed in the axillary fossa along the course of the vessels in such a manner as not to compress them. The skin was sutured with silk. Duration of the operation fifty minutes.

During the operation careful search was made for enlarged axillary glands in the expectation of finding evidence of metastasis, but apparently the main group of glands was free from involvement. However, palpation in the region of the digitation of the serratus magnus arising from the third rib revealed a few enlarged lymph nodes, which were removed for examination.

Recovery was uneventful, and the patient was discharged from the hospital with the advice to undergo a course of postoperative radiation treatment.

On pathological examination a stony hard mass the size of a walnut, lying in the upper

the tumor was found to be cystic and exuded a dark brown fluid. The lining membrane of the cyst appeared reddish brown and hyperplastic. No other masses could be found in the breast.

Microscopically, the growth showed numerous large cystic cavities, from the walls of which sprang numerous papillomatous proliferations composed of ill-defined anaplastic epithelial cells in all stages of mucoid degeneration. The entire histological picture closely resembled that of a multilocular proliferating papillary cyst of the ovary. In other sections, mucoid degeneration had advanced so far that individual cells could hardly be recognized.

Sections from the lymphatic glands removed from the region of the serratus magnus showed a large part of the lymph node to be replaced by cellular areas composed of large pale epithelial cells, which by contrast with the deeply stained surrounding lymphatic tissue appeared still paler. These cells were identical with those found in the original tumor. The axillary glands revealed no malignancy.

The pathological diagnosis was gelatinous cyst adenocarcinoma of the breast with metastatic colloid carcinoma of the lymph nodes in the region of the third digitation of the serratus magnus.

The pathological examination was conducted by Dr. A. A. Eisenberg, to whom I wish to express my best thanks.



# PSEUDOPERITONITIS

## DUE TO EXTERNAL TRAUMATISM\*

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THE value of criticism lies not so much in uncovering mistakes as it does in finding means by which we may avoid future occurrences of similar mistakes. That many abdominal operations are performed and nothing found to account for the symptoms of which the patient had complained, is a fact well known to surgeons.

Articles that have been written in the past on the subjects of pseudoperitonitis, or peritonism, and pseudo-ileus deal, mainly, with medical conditions as the causative factors. Several cases have been observed by the writer in which the causative factor was a traumatism. In our present age of automobile and industrial injuries, there must be many instances in which accidents of a similar nature occur. It is with this in mind that an attempt is made in this article to clarify the diagnostic difficulty with a view to avoidance of unnecessary abdominal sections. One might say that no harm has been done by opening an abdomen under strict aseptic precautions, as practiced today, which may be true. Our contention is, however, that any refinement in diagnosis, which will help us recognize the uselessness of an abdominal operation in a given case, is a goal toward which every surgeon must strive. Not every section is entirely free from dangerous sequelae.

The first paper, dealing with these subjects, was written in 1865 by A. H. Henrot of Paris. Then follow papers on both subjects naming as causes: Intestinal ptosis, intestinal parasites, uremia, syphilis, hernia, ureteral calculi, pneumonia, instrumental delivery and adherent placenta, calcified mesenteric glands, heart disease,

lead poisoning, diabetes, and hysteria. Nowhere in the literature have we been able to find mention of external traumatism as a cause of peritonism. We cite 5 cases and then attempt to formulate some plan of procedure in this type of case to enable us, if possible, to make a definite diagnosis.

CASE 1. A man, twenty-two years old, fell from a scaffold, 15 ft. high. He was immediately transferred to the Syracuse Memorial Hospital. He complained of severe pain in the left hypochondriac region. His skin was cold and clammy; pulse, 120; and respirations, 40. His only complaint was severe pain in the upper, left abdomen and lower back. The physical examination was negative, except for a marked rigidity of the upper, left rectus and tenderness, on pressure in that region and disclosed a swelling in the lower lumbar region of the spine. The man had fallen on his back, landing first in a half-sitting position and then rocked onto his neck, so the possibility of a fractured vertebra was kept in mind. Although at the time, the picture of an intra-abdominal lesion was not definite, consultation with the attending chief surgeon on the staff decided us in making an exploratory laparotomy. Careful examination of the stomach, transverse and descending colon, left kidney, spleen and small intestines disclosed no lesion. All organs appeared normal. The patient's temperature rose to 101°F., rectally, and in three days was normal. His pulse rate gradually receded from 120 to normal in the same number of days. He was discharged from the hospital twelve days after admission, during my absence from the city. Finding, on my return, that he had been discharged, I saw him at his home and had him return to the hospital for an x-ray of his spine because of my suspicion that we were dealing with a fracture. The posterior bulging in the lumbar region was definite, and the plates showed a compression fracture of the fourth lumbar vertebra. A plaster jacket was applied. He is well today.

\* Read before the 42nd Annual Meeting, American Association of Obstetricians, Gynecologists, and Abdominal Surgeons, Memphis, Tenn., September, 1929.

CASE II. A child, four years old, was brought to the Syracuse Memorial Hospital following a coasting accident. He had a contusion and swelling of the soft parts on the left side of his neck, and a few skin abrasions of the face. He had no other marks on his body. His respirations were rapid and of a grunting character, such as one sees in irritation of the peritoneum in children. The abdomen, in its upper half, was held rigid. The possibility of a ruptured viscus decided us in opening the abdomen, but nothing was found.

CASE III. An Italian laborer had a sudden pain in his upper abdomen, while lifting a door. After two days his physician sent him to the hospital with a diagnosis of acute cholecystitis; the surgeon, who saw him, concurred in this diagnosis. The blood count and temperature were normal. The upper abdomen, however, was markedly rigid and very tender. He had vomited once before admission to the hospital. A longitudinal incision was made. The gall bladder was normal, but a hemorrhage was noticed in the falciform ligament. When this was cut down upon, a clot, the size of an English walnut, was found; removal of this revealed active oozing. His convalescence was stormy because of hiccoughs for three days.

CASE IV. A woman, aged thirty-eight, was brought to the Syracuse Memorial Hospital, having been crushed between an automobile and a tree. Upon admission she was found to have severe pain in the chest and abdomen, numbness and coldness of her legs, and was unable to raise her legs. Examination revealed marked tenderness in the lower abdomen, considerable distention, and rigidity. Tenderness was very marked over the pelvis. X-ray examination of the pelvis showed a fracture through both acetabuli, also two fractures of the inferior ramus of the right pubis. There was practically no displacement of the former, but some of the latter two. Distention persisted for about eight days, gradually subsiding in fourteen days. Tenderness was a constant symptom. During the earlier part of her stay at the hospital, the patient was incontinent, but after twenty-seven days she gradually overcame this difficulty. At no time was her temperature over 100°F. No operation was performed.

CASE V. A woman, twenty-nine years of age, came to my office. Her chief complaint

was pain in the epigastrium and the left hypochondrium. This pain had been persistent for about one year and, at times, quite severe.

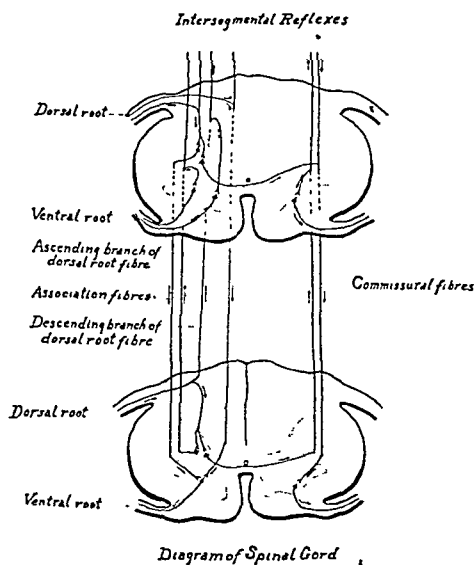


FIG. 1.

Examination disclosed definite tenderness over these areas, but it also extended along the course of the left, sixth, thoracic nerve to the postaxillary line. X-ray examination revealed no abnormality of the vertebrae or ribs. An inch of the sixth thoracic nerve was resected in the postaxillary line, and she has been free from symptoms since.

It is the purpose of the writer to explain how impulses may arise at one level; that is, an injury at the level of one vertebra may produce symptoms at a higher level through purely intraspinal connections. The diagram (Fig. 1) and explanatory notes will make this clear.

We are particularly interested in a description of an impulse, which will cause a reaction at a higher, sometimes much higher level than that at which the injury occurs, or in some instances, the opposite. One of the means through which this mechanism occurs, is the dorso-lateral tract of Lissauer. In the diagram this is labeled "ascending branch of dorsal root fiber." It will be seen that the impulse enters the posterior root and then runs upward in the posterior funiculus of the cord, that is, in the white matter of the cord. It finally ends in one of the higher

segments of the cord and, in some cases, even in the gray matter of the brain. In this higher segment, the fiber forms a synapse in the gray matter of the cord with the motor pathway that goes to the area supplied by the emerging motor nerve in the ventral root.

Another means by which an ascending impulse may be conveyed is shown in the diagram. Following the arrows, entering the posterior root, it will be noted that there is a division of the fiber. The fiber running cephalad has been described. The one running inferiorly in the diagram is shown to divide again, and these divisions are shown to form synapses in the gray matter. It is the lateral of these two synapses with which we are now concerned. After the synapse, which takes place in the same segment, it will be noted that we again have a fiber running upward. This fiber is known as an association fiber and is so labeled. It will be seen that it makes a similar synapse in a higher segment, as the one already described in the tract of Lissauer; the final impulse is the same. In the diagram, a fiber is shown running parallel to the one just described, with the arrow pointing downward. The impulse conveyed by this fiber may run through several segments passing in the opposite direction, and through this latter mechanism, injury high up may manifest itself in an area below.

In the case of the fractured fourth lumbar vertebra, had we been dealing with a ruptured spleen or kidney, a blood count would have given evidence of hemorrhage by a lowering hemaglobin and red cell count. In cases of this sort, blood counts should be done not once, but several times in the course of an hour or two. Blood in the urine would have given evidence of a kidney lesion. A ruptured viscus would have given evidence of gas in the abdominal cavity, possibly absence of liver dullness. In addition, either of these conditions would be accompanied by marked shock. It is not necessary to go into further detail in the matter of physical findings

in acute abdominal crises, which are the result of definite lesions to the viscera. They are well known and should be kept in mind by the surgeon. Case I had none of these findings, the only symptoms in common with direct peritoneal irritation were rigidity and pain. Had we known of the possibility of reflex arcs, such as described, causing this sort of disturbance, undoubtedly, we would have waited and watched our case for some time before doing a laparotomy, as we shall do in the future.

In Case II we had but two symptoms resembling peritoneal irritation; viz., a fairly rigid upper abdomen with apparent distention. Investigating this case from a physiological standpoint, we have been informed that it is quite possible that a blow of enough severity to irritate the phrenic nerve in the neck might cause a spasm of the diaphragm on the same side. The contusion in this case was over the area between the third and fourth cervical nerves, in other words, at the origin of the phrenic. It is not, in my opinion, beyond possibility that in this case our upper abdominal rigidity was caused by this injury. We are aware of the resemblance to peritonitis caused by a pneumonia with a diaphragmatic pleurisy. The child was sitting up in bed on the day following the operation and made, as Baldwin puts it, "a very uninteresting recovery." In another case of this type wait and watch will be the order.

Case III is included because of its unusual character, and because we felt that it fitted in with cases of pseudoperitonitis. It was the result of traumatism, and we were privileged to observe it. A hemorrhage into the falciform ligament of the liver, an entirely extraperitoneal structure, caused symptoms which, three men agreed, resembled cholecystitis. There was no rise in blood count, no history of indigestion; in fact, nothing definite except epigastric pain and one attack of vomiting.

Tenderness and pain from injuries in the abdominal wall may be differentiated

from deeper-lying causative factors; in that light palpation elicits pain, whereas it does not in deep-seated pathology. In this case there was absolutely no evidence of peritonitis on inspection after the abdomen was opened. We cite this case merely to put it in the literature as another etiological factor in pseudoperitonitis. The stormy convalescence with hiccoughs shows that simple laparotomy is not always without danger.

Case iv is not an uncommon type and is mentioned to show how peritoneal irritation in pelvic fractures may cause distention, pain and rigidity resembling an "acute abdomen." Nothing was done in this case in an operative way. This woman made a fine recovery in all respects.

Case v is a very interesting type. Subcostal neuralgia has been spoken of as a cause of symptoms resembling those due to pathology of internal organs. Cases have been cited in which several abdominal operations were performed, relief finally being obtained by section of the nerve. In our case, before the nerve was sectioned a 2 per cent novocaine solution was used as a block anesthetic. This was injected around the nerve, posterior to the angle of the sixth rib. The patient immediately stated that the pain had stopped. Palpation revealed no area of tenderness in the epigastric or left hypochondriac regions, or along the course of the nerve. Here then we had proof that section would relieve the pain. This was done with, until now, gratifying results.

This last result has given us the impression that, possibly, in cases of the type

found in Cases I and II, a block anesthesia along the peripheral nerve or nerves supplying the segmental area affected, may aid in the differential diagnosis between traumatic pseudoperitonitis and actual visceral damage. In case the pain is relieved following the injection, and no pain or tenderness develops in another area, such as we see, for instance, in a case of perforated, gastric ulcer, where the pain may gradually go downward from the epigastrium to the appendiceal region due to peritoneal irritation of the gastric contents running down the right gutter, we may presume that a viscus is not injured, and that we may safely wait. Naturally, blood pressure, blood count, temperature, etc. would be carefully noted meanwhile, and noted frequently.

#### SUMMARY

1. The type of case with which this paper deals is one which demands the minutest and most painstaking personal care of the surgeon himself.
2. The decision whether to operate or not to operate must be made in a matter of a few hours.
3. Keeping in mind the possibility of distant traumatism as a factor in the causation of symptoms resembling those due to actual peritoneal inflammation, it but remains for the surgeon to stay with his patient and to carry out meticulously all the essential clinical investigations, which will show actual peritoneal injury.
4. Use of block anesthesia during this time is suggested as an aid in the diagnosis.

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# CALCULUS OF THE UPPER URINARY TRACT\*

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WE wish to present certain data concerning 70 patients with calculus of the upper urinary tract, operated upon at Bellevue Hospital by the staff of the Urological Service; also to state briefly our present attitude toward certain problems encountered in this work.

## RENAL CALCULUS

There were 164 patients discharged from the hospital the past six years with the diagnosis of nephrolithiasis. Forty-eight of these were operated upon and form the basis of this review. Three were readmitted for operation on the opposite side.

Our wards always contain a relatively large proportion of individuals of foreign birth, and it is therefore not surprising that 11 nationalities were represented in this group. About one-third were born in the United States and an equal number in Italy. As to the age incidence, our patients were about equally divided below and above forty. Our youngest case was twenty, and the oldest seventy-three. Hospital rules prohibit the admission of children under fourteen years of age in the Urological Service.

*Complaint:* The most frequent complaint was loin pain, noted in 80 per cent, while abdominal pain was recorded in 15 per cent of the cases, urinary frequency in 12 per cent and hematuria in 10 per cent. Occasional complaints were anuria, foul-smelling urine, dysuria, loss of weight, weakness, nausea and vomiting, headache, testicular pain and multiple arthritis.

*Past Urinary History:* Thirty per cent only had had previous ureteral colic; 7 per cent previous attacks of hematuria; 10 per cent had passed a stone; nearly 15 per cent had had previous operation for calculus; and 12 per cent (all with right renal stone) had submitted to appen-

dectomy, quite possibly because of ureteral pain.

*Examination:* Tenderness in the kidney area posteriorly was found in nearly 60 per cent of the cases. Abdominal tenderness occurred in about 30 per cent. The renal function on the diseased side in unilateral stone cases as compared with the other kidney, was determined by the urea content of the urines, and the output of indigo carmine and phenolsulphone-phthalein. It was found that the function was decreased in 70 per cent of the kidneys harboring stones. Curiously in 3 instances the function as indicated by these tests was really increased. Infection of the urine obtained from the calculus side was present in nearly 85 per cent. The pyelograms showed some dilatation of the pelvis or calyces in 95 per cent but rarely if ever the irregular outline of kidney destruction.

Of the bilateral stone cases, we call particular attention to 3 patients, whose output of phthalein in two hours before operation was surprisingly large, 65 per cent, 50 per cent and 50 per cent respectively. In these patients, the complaints demanding operation were renal pain in all, chills and fever in 1, and hematuria in 1.

## ILLUSTRATIVE CASE REPORTS

For contrast, the following 2 interesting cases of bilateral calculus disease are cited.

CASE 1. E. B., male, aged forty-eight, entered the hospital complaining of pain in both flanks. He had had a pyelotomy for stone fifteen years earlier. He had been under the observation of one of us for five years, and had sought advice because of cloudy urine. Ureteral catheterization had repeatedly demonstrated infection of both kidneys, and the phthalein report was excellent, although roentgenograms showed stones on both sides

\* Submitted for publication February 21, 1930.

(See Fig. 3). But there were no symptoms and the general health was good over this period. Finally chills and fever developed,

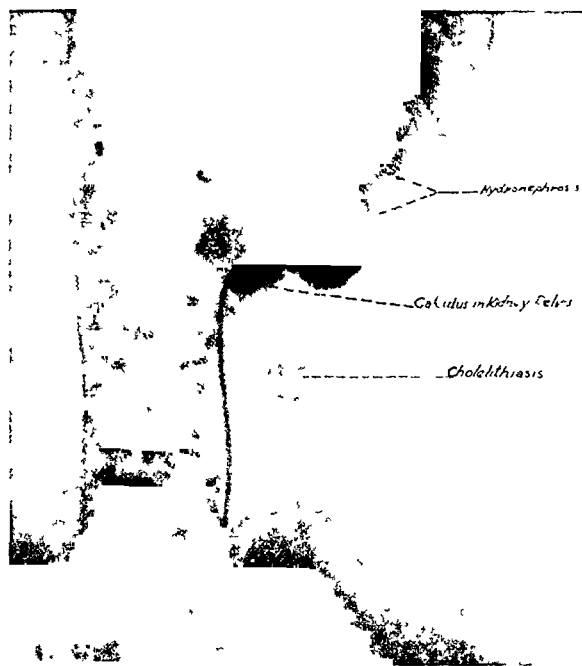


FIG. 1. Calculus in renal pelvis producing hydro-nephrosis. Eleven stones in gall bladder.

with severe pain in both kidney regions. On admission to the hospital, the patient's

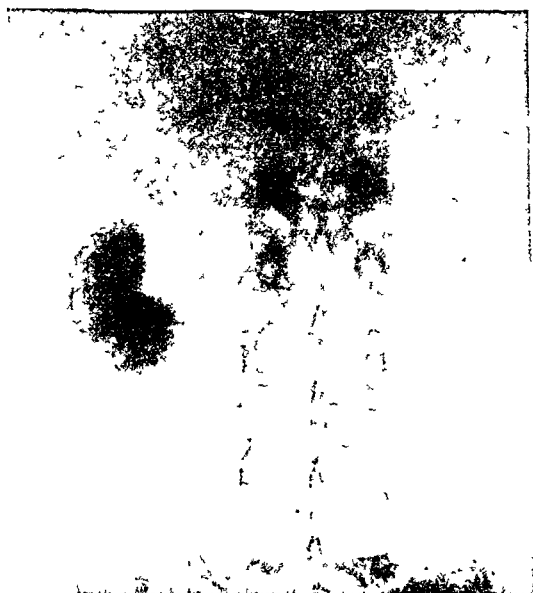


FIG. 2. Multiple calculi in one kidney. Kidneys show equal function and no infection. Yet for thirty-seven years patient has had occasional hematuria, especially after exercise, without pain. Operation not advised, as condition good and patient comfortable.

phthalein output in two hours was 65 per cent. The right kidney gave but a trace of urea, no

indigo carmine, but some pus and micrococci; the left kidney gave 0.5 per cent urea, blue color in eight minutes, pus and micrococci. Left pyelotomy and nephrotomy were done for multiple calculi (Fig. 4). Phthalein output on discharge was 25 per cent. On readmission, four months later, it was 30 per cent. The right kidney gave no urea, no dye, but much pus and cocci; the left kidney gave 0.3 per cent urea, pale blue color, clumps of pus and some cocci. Right nephrectomy was performed for advanced calculus pyonephrosis. Two weeks after operation, the phthalein was 40 per cent in two hours. Patient continues in good health to date, eight months after operation.

CASE II. C. A., male, aged thirty-two, entered hospital complaining of pain in the left loin, foul urine, headache and nausea. Non-protein nitrogen in the blood plasma was 145 mg. per 100 c.c., and creatinine was 3.6. Cystoscopies showed thick ribbons of pus from both ureters; there was no phthalein output in eighteen minutes, and no indigo carmine in twenty-five minutes from either side. Roentgenograms proved calculi in both kidneys. The usual medical therapy was persisted in but availed nothing; surgery in

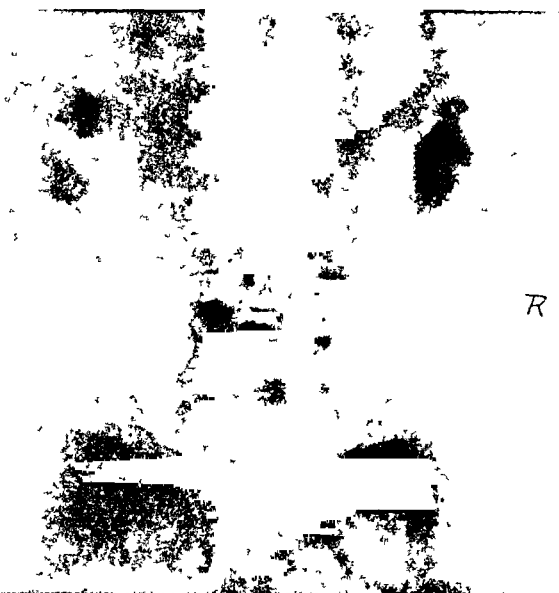


FIG. 3. Bilateral calculi. Multiple stones removed from left kidney. Later right nephrectomy for calculous pyonephrosis.

our opinion was contraindicated. The patient became gradually worse, with vomiting and other evidences of toxemia and died on the seventeenth day. N.P.N. three days before

death was 132, creatinine 4.0; one day before death, N.P.N. was 282 and creatinine was 5.7.

*Anesthesia:* In the earlier cases of the



FIG. 4. Stones removed from left kidney of case shown in Fig. 3.

group here reported, general anesthesia was used. Having used spinal anesthesia with increasing satisfaction in perineal and suprapubic work the past ten years, we were led to try it in kidney and ureteral operations, as the technic had improved and the safeguards multiplied. In 1928 spinal anesthesia was used in 11 kidney operations. Three of these, lasting over one hour, required some general anesthesia at the close. Contrary to the opinion expressed by some anesthetists, we find that patients under spinal anesthesia take the added general anesthesia with particular ease. Spinal anesthesia gives marked muscular relaxation during the operation, leads to less postoperative distention, less gastrointestinal upset and fewer re-

spiratory complications. For routine work, we believe it to be the method of choice. However, it must be employed only with a thorough knowledge of the technic and dangers. The great risks are anesthesia of the medullary centers and rapid fall of blood pressure. To combat the former, the spinal puncture is done with the patient lying on one side, and the head is kept lower than the hips during and after operation. To combat the latter, we depend almost solely upon ephedrine. Uniformly a subcutaneous injection of 50 mg. is given at the time of the spinal tap. An interne is detailed to watch the blood pressure, and further injections of ephedrine, subcutaneous or even intravenous, are given as indicated. However, spinal anesthesia is not for universal application. There are some emotional and apprehensive patients who are constitutionally unfitted for it.

*Operation:* An oblique loin incision parallel to the costal margin and keeping above the twelfth dorsal nerve, is almost always employed by us. In some cases, the stone is easily felt in the pelvis or upper ureter, and readily removed without shelling the kidney from its fatty capsule. We believe this should be done when feasible. Otherwise the kidney is freely mobilized and brought out of the wound if the length of the pedicle permits. It seems universally agreed that pyelotomy is preferable to nephrotomy. When incision of the renal cortex is necessary we prefer to extend the pyelotomy wound into the kidney parenchyma upward or downward as the position of the stone indicates, carefully avoiding visible vessels. Any bleeding vessel may be carefully clamped and tied. Often such hemorrhage is quickly and is preferably controlled by pressure. These kidney incisions are closed by a few superficial mattress sutures placed in the capsule. We have avoided deep through and through sutures as tending to cause pressure necrosis, at times additional hemorrhage, and postoperative infection. This superficial suture

has completely controlled the bleeding. When isolated calculi are present in calices, it may be necessary to cut the convex

case leaked urine forty-two days; this healed only after several indwelling ureteral catheters had been used.

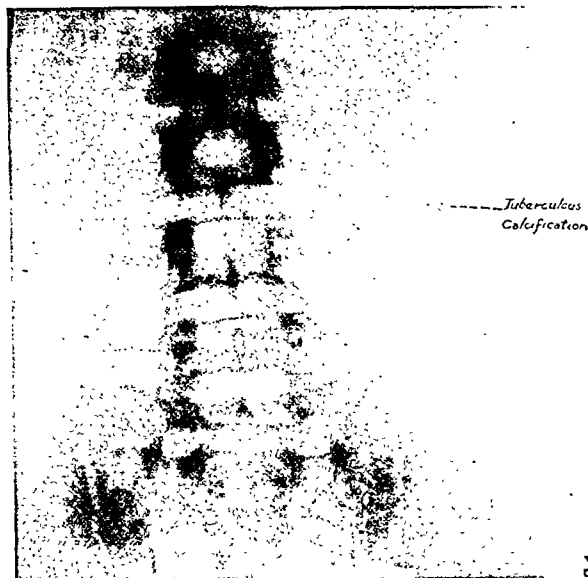


FIG. 5. Tuberculous calcification in lower calyx of kidney resembling renal calculus.



FIG. 6. Calcified lymph node outside middle calyx.

surface of the kidney parenchyma. We prefer multiple small incisions to one large one. After doing nephrotomy, we always incise the pelvis and leave it open for drainage. There were 10 cases requiring nephrotomy in this group. None had subsequent hemorrhage nor any secondary operation.

It has been a question with us for some time whether suture of ureterotomy or pyelotomy wounds hastened the healing. Some of these cases without suture have never drained urine, and we are using sutures in decreasing numbers. At present only the larger incisions are sutured and they only partly so. If there is no obstruction, leakage from a ureteral incision will be little; the normal peristalsis carries urine toward the bladder. If there is some permanent or even temporary obstruction, it is much better for the patient that an opening in the ureter be left.

**Wounds:** No clean wounds in this series, that is, wounds leading to uninfected kidneys, became infected. All wounds but 3 of 15 pyelotomy cases with definite notes, healed flush with the skin within twenty days; 2 in twenty-five days. One

The nephrectomy wounds healed on an average of one week earlier than the pyelotomy wounds.

Of the whole series of kidney cases, 4 wounds had to be opened because of infection.

**Stay in Hospital:** About 40 per cent of the patients left the hospital fifteen to nineteen days after operation; 40 per cent in twenty to twenty-eight days; and 20 per cent remained in hospital over four weeks.

**Deaths:** Of the 51 patients having renal calculus who were operated upon, 8 died. Believing that our failures are of particular interest, we record a few facts concerning these 8 deaths. All of them occurred within two weeks after operation; 2, within twenty-four hours. Perhaps it is only fair to state again that this series of operations for renal calculus with such a high mortality rate concerns only patients of a municipal hospital. A large percentage of these patients are admitted in very bad condition, and circumstances frequently compel us to take grave risks (Note Cases III, VI, VIII-X following).

CASE III. Male, aged sixty-three, had a



large calculus removed through a pyelotomy incision. He was in a weakened condition with a poorly functioning heart, but operation had to be performed because of continued pain. Condition satisfactory immediately after operation, but patient became gradually weaker and died of myocarditis two weeks after operation.

CASE IV. Male, aged thirty-three, was operated upon for stones in the renal pelvis. The pedicle was accidentally torn during the dissection, severe hemorrhage ensued necessitating nephrectomy. Patient died in twelve hours.

CASE V. Male, aged forty-seven, had a nephrotomy for calculus. Previous cystoscopy showed no infection of either kidney. Condition satisfactory until the thirteenth day when the patient suddenly became cyanotic and died. The attending physician diagnosed coronary embolism. No autopsy.

CASE VI. Male, aged fifty-nine, had right nephrectomy for calculus pyonephrosis. General condition poor before operation. N.P.N. was 60 and creatinine 2.5 four days before operation. Phthalein tests 20 per cent in two hours one day before operation. Because of pain in the kidney region and infection, operation was imperative. Condition improved little after nephrectomy. On the tenth postoperative day, there was a chill with temperature 101°F., and severe sharp pain in the right lower quadrant. Patient died the next day; no autopsy. Probable cause of death was thrombosis.

CASE VII. Male, aged thirty-four, was admitted with bilateral renal calculi, a large dentritic stone on the right side, and a large calculus in the left pelvis. On cystoscopy, the right ureter gave thick pus, no urea, no dye; the left ureter, no pus, good urea, and phthalein in seven minutes. Under spinal anesthesia, the very adherent right kidney was removed. Temperature after operation registered from 101 to 104.6°F., the pulse was rapid and abdomen markedly distended. Distention could be relieved only temporarily, and patient died on fifth postoperative day. No autopsy.

CASE VIII. Male, aged fifty-four, entered hospital with pain in right loin and hematuria. Roentgenograms showed stones in both kidneys. On cystoscopy, right ureter discharged thick pus, and left ureter clear urine; no

indigo carmine came from either kidney in eleven minutes. N.P.N. ten days before operation was 56; creatinine 3.0. N.P.N. five days before operation was 100, creatinine 3.0. Perinephritis abscess became apparent and was drained; no further operation done. On second postoperative day, N.P.N. was 300, creatinine 4.3. Condition steadily grew worse, and patient died on seventh day after operation. No autopsy.

CASE IX. Male, aged forty-three, was admitted with severe pain in the right loin, vomiting and headache. He had been operated upon for stones in the right kidney two years earlier, and had had a litholapaxy a year before that. N.P.N. a week after admission was 200, creatinine 2.6; twelve days later, N.P.N. was 30, and creatinine 2.2. No cystoscopy, the right kidney gave a faint trace of indigo carmine and 0.65 per cent urea; left kidney, medium color and 1.1 per cent urea. There was some infection on both sides. Because of the poor condition, no operation was done until six weeks after admission. However the pain continued and operation seemed imperative; the right kidney was removed under general anesthesia. Operation was not unduly prolonged, yet the patient went into shock on the table and died the next morning. No autopsy.

CASE X. Male, aged fifty-three, was admitted with a history of anuria for twenty hours. Was relieved by indwelling catheters for three days when he insisted on going home. He was able to urinate for four days, then developed trouble again and returned after three days of anuria. Double indwelling ureteral catheters were introduced at once. The next day N.P.N. was 84 and creatinine 4.5. Five days later, (the catheters having been withdrawn), the N.P.N. was 230; the catheters were reintroduced. Several phthalein tests done at various times gave zero output in two hours. Roentgenograms showed small shadows at the uretero-pelvic junctions on both sides. From time to time the ureteral catheters were withdrawn; patient would become anuric and uremic, and catheters would be reinserted. Finally on the twenty-fifth day after admission, N.P.N. was 56 and creatinine 3.2. Operation offered the only hope of permanent relief, as otherwise better condition was dispaired of. Right pyelotomy was finally

performed and stone removed. There was considerable infiltration of the perinephritic fat noted. Patient died three days later. Autopsy showed a small right kidney with perinephritis; calcareous incrustations and thickened wall of the corresponding ureter, 2 cm. below the pelvis. The left kidney was large (25 cm. long) and had purulent material in the pelvis; at the uretero-pelvic junction there was a calcific deposit obstructing the ureter.

#### URETERAL CALCULUS

There were 153 patients discharged from the hospital during the past six years, diagnosed "ureteral calculus." Of these, 22 were operated upon by our staff.

As with our patients having renal calculus, over half of this group of 22 ureteral cases were born in this country or Italy. Considering their ages, 9 were in the fourth decade of life, 6 in the third, and 6 in the fifth decade, while but one was over fifty.

*Complaint:* Pain was the outstanding symptom; in 12, it was referred to the back; in the other 8, to various parts of the abdomen (1 to the penis). Hematuria was complained of but twice, anuria once and urinary frequency once.

*Past History:* Pain had occurred on the same side which was the seat of the present trouble, in 5 instances, from one-half to eight years earlier; hematuria, once, two years before; stone passed from the same side, once, two and one half years before; ureterotomy, once, eight years before; appendectomy on side of present trouble, once, eight years earlier.

*Present Illness:* Eighteen cases had pain in the kidney region; 3 had unilateral abdominal pain. Of these 21 patients, 8 had radiation of the pain to the groin or testicle.

*Examination:* There was costovertebral tenderness in 15 patients, and abdominal tenderness in but 3, while 6 patients presented no tender area.

As the general phthalein test was usually good before operation, there could be no

appreciable improvement thereafter; no case showed a decrease of output after operation. The only interesting observation on blood chemistry concerned a patient with bilateral ureteral calculi, causing almost complete anuria. His N.P.N. jumped from 55, five days before operation, to 137 on the day of operation, creatinine going from 1.5 to 4.5. Four days after double pyelotomy both constituents were normal.

Catheters were made to pass the ureteral stones in all cases but 4. The renal function on the involved side was decreased in 14 of 15 cases where ureteral specimens were obtained; one showed no decrease. The function on the involved side showed definite improvement in all of 5 cases tested after operation. There was demonstrated dilatation of the urinary tract above the stone in all of the 4 patients in whom clear pyelograms were obtained.

Infection was present on the involved side in 11 of the 15 cases. After operation, the infection was absent in 2 cases cystoscoped, decreased in 1, and unchanged in 1. The uninvolved kidney was found infected twice and uninfected in 16 cases.

*Operation:* Incisions naturally varied with the location of the stones. They were high, practically as for a kidney operation, and low (over pelvic ureter) in about equal numbers. The low incisions were usually oblique, following in general that described by Gibson. In 4 instances the vertical mid-rectus incision was employed and found very satisfactory for stones near the bladder. However, we believe the oblique incision affords an easier approach in the larger number of cases. The stones were found and removed in all but 2 instances. In one of these the calculus slipped back to the kidney, was not found in the renal pelvis at this time, but was removed from the ureter at a later date. The other failure concerned one side of a patient in almost complete anuria from double ureteral calculi. We had one experience of failure to secure a stone low in the ureter, but opened the bladder at once

and obtained it from the intramural portion.

Ureteral stones sometimes change position markedly without causing pain. Hence we uniformly require that a confirmatory roentgenogram be made just prior to operation. At operation, ureteral calculi do not easily move down the ureter, but may readily slip up toward the kidney. It is a useful procedure to dissect above the stone as early as possible and place a tape under the ureter above the stone.

As stated earlier, we place sutures in the ureter only in instances of long incisions. Adequate drainage is obviously necessary.

Our preference for spinal anesthesia has already been stated, and it has been employed with great satisfaction in these cases for nearly two years.

*Wounds:* Two cases had no leakage of urine from the wounds. The others leaked for varying periods up to twenty-six days. If leakage continues after ten to fourteen days, a catheter is passed up the ureter and allowed to remain for a day or two.

*Stay in Hospital:* In this group of 22 operations for ureteral calculus, there were no deaths. Three (14 per cent) went home in eighteen days after operation; 11 (50 per cent) in twenty to twenty-nine days; 8 (36 per cent) in thirty to forty days. The last group represents chiefly badly infected wounds, the infection having been present in the corresponding kidney before operation. One patient had probable femoral thrombosis, but was discharged on the thirty-sixth day. One case with postoperative epididymitis was discharged on the thirty-second day. Apparently, patients stay in the hospital longer after ureteral operations than after kidney operations for calculus.

#### BILATERAL CALCULUS

The problem of bilateral calculus disease of the upper urinary tract has often been discussed. The usual advice is to operate first on the side having the better kidney. But some will decide this question on the

basis of the comparative function tests of the kidneys as found before operation. This may be very misleading. The better kidney may be functioning badly for the time being, because of ureteral obstruction. It is necessary to consider the position of the calculi and to note the possibilities of obstruction, as this factor is the most potent one for immediate harm. Hence our feeling is that each case presents a problem unto itself. Having studied the patient, the cystoscopic and functional reports, and the roentgenograms, we advise operation first on that stone, the removal of which will enhance the total renal function the most.

#### CALCULUS ANURIA

There are differences of opinion concerning methods of treating patients with complete blockage of one or both ureters. Prolonged trial of palliative measures is to be condemned. The patient should be placed in a hospital where operation can be performed at a moment's notice. Cystoscopic methods will often relieve the obstruction, at least temporarily, will thus allow time for further study, and will put the patient in better condition should operation become necessary. Furthermore, in some instances, a flow of urine will become established, after the ureteral catheters have been removed, and the patient may ultimately pass the stone, if small. Continuous observation is urgently required, with frequent estimations of renal function. If this decreases, or the anuria recurs after the removal of the ureteral catheters, immediate operation is imperative. If the condition remains good, but the stone does not move, operation will probably be indicated, but the emergency has passed.

#### INDICATIONS FOR OPERATION

We wish, in closing, to consider briefly which stones in the kidney and ureter should be operated upon, and which should be left alone. As in all realms of surgery, one must fairly consider whether

the probable benefit to follow operation will compensate for the possible harm and risk.

Operation is usually indicated on kidney stones associated with reduced renal function; coincident infection increases this demand. The chances of eliminating infection accompanying stone without removal of that stone is slight. The stone should be removed through a pyelotomy incision if it seems feasible to do so. If the stone is small and so placed in the calyx that nephrotomy will be required, it may be questioned whether such an operation will not do more harm than good. Either persistent pain or hematuria is an indication for operation. Silent stones without infection, hematuria, pain, or diminished renal function, we think should be left alone.

As for ureteral calculi, we agree with the general view that all these stones should be ultimately removed, and that stones casting shadows 1 cm. or more in diameter will probably require operation. We have had patients pass such large stones, but this is not the rule. Smaller stones can usually be made to come away by cystoscopic manipulations. There is danger in prolonging these efforts; irreparable damage may ensue. Diminished function of the kidney, especially decreasing function and most particularly anuria, demand an early operation.

#### SUMMARY

1. We present data concerning 70 patients operated upon at Bellevue Hospital for calculus disease of the upper

urinary tract; these represent 51 kidney operations and 22 ureteral operations.

2. The vast majority of our patients come to the hospital for the relief of renal pain.

3. Kidney and ureteral stones usually decrease the renal function, and increase any existing infection.

4. Spinal anesthesia has been used with great satisfaction in the more recent operations.

5. Pyelotomy is the operation of choice for kidney stones; a pyelonephrotomy or a nephrectomy may be necessary.

6. Only the larger pyelotomy and ureterotomy incisions are sutured after the removal of the stone.

7. Following the 51 operations for stones in the kidney, there were 8 deaths, most of which occurred in desperately ill patients with trouble of long standing and with symptoms demanding operative relief. There were no deaths following the 22 ureteral operations.

8. A curved loin incision is used for kidney and upper ureter stones; the oblique Gibson incision for lower ureter stones.

9. In cases of bilateral calculi, as a general rule operate first upon the stone, the removal of which will most markedly enhance the total renal function.

10. Indications for operation are, diminishing function, increasing infection, anuria, ureteral stone over 1 cm. in diameter, persistent pain, and recurring hematuria.

11. All ureteral stones should be ultimately removed by cystoscopic manipulations preferably, or by operation.



# GONORRHEAL INFECTIONS OF THE BLADDER & KIDNEYS\*

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AS far as the bladder is concerned, it may very definitely be stated that only one part of it is ever involved in a gonorrheal infection. The region affected is a triangular area in the bladder neck, known as the trigone. It extends along the bladder floor from the orifices of the ureters to the internal urethral opening.

Its structure is practically identical with that of the urethra and the ureters. In all its other portions, the bladder structure is very different and apparently non-susceptible to gonococcal attack. We can thus eliminate bladder disease per se in gonorrhea. When a deep infection of the urethra is present, as it invariably is in all cases, the trigone also carries the burden of the disease. In these cases, however, there is much greater danger of the infection passing up into the kidney, than there is of its going over the trigone border into the bladder proper.

It has always been our impression that considerably more gonorrheal disease of the kidney exists than we realize, but a careful survey of living and autopsy material has failed to confirm this belief. Throughout a period of almost thirty years we have encountered only one case in our own practice, although we have seen 4 in the service of other physicians. The entire literature shows but 27 cases reported. Are these cases the result of a systemic or an ascending infection? We are inclined to believe that they are part of a so-called gonorrheal septicemia or blood poisoning.

Simmons a few years ago surveyed this situation in a very thorough way. The possibility of infection reaching the kidney immediately suggest two likely ways: the blood or via the urinary system. During

the course of most acute infectious diseases, bacteria have been proved to enter the blood stream.

This has been shown repeatedly in the case of the gonococcus. The frequent gonorrheal inflammation of the heart and so-called gonorrheal rheumatism demonstrate not only that the gonococcus enters the blood stream but also suggest in a very modest way the frequency with which it does so.

It has been demonstrated also that bacteria may readily pass from the infected blood stream through the normal kidney without producing disease. If these bacteria are few in number or of the less violent type the healthy kidney does not become infected. If, however, they are abundant and of a violent strain, or if there exists a defect in the kidney itself, or one resulting in the stagnation of urine in the kidney pelvis, an infection of that organ will occur. As these conditions are rarely fulfilled, in an attack of gonorrhea, the infrequency of gonorrheal kidney complications is probably thus explained.

Simmons further states that the urinary route, upon superficial consideration, suggests the more likely source of kidney infection. However, when the defensive mechanism of the urinary system is considered, this route must be of secondary importance particularly in gonorrheal infections. The usual port of entry for the gonococcus is the anterior urethra. By direct extension, in a certain number of cases, the infection reaches the bladder neck, as we have shown. The ureter, however, seems doubly protected against further invasion. These are very important points in medico-legal cases. The ureter is first protected by the sphincter action of the bladder wall or the ureter. As a

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matter of fact there is really a fold of tissue forming a valve at the entrance of the ureter into the bladder. This fold holds so strongly that unless it is diseased we cannot force fluid up the ureter by over-distending the bladder. A second preventive barrier is the continuous flow of urine from the ureter into the bladder.

Any inflammation starting in the ureter at the bladder would also of itself tend to prevent an extension upward of the disease. Several other routes have been proposed for kidney infection. One is by a special utero-renal circulation demonstrated by Sampson, but this in reality does not actually touch the kidneys. The remaining source of infection is by the lymphatic channels. At this time there is a connection between the lymphatics of the bladder and the kidney, but it is interrupted so often that it does not seem a likely channel. I think the only case of record that could definitely be linked with lymphatic extension was an instance of multiple gonorrheal abscesses reported by Stanton in 1913.

To obtain definite proof that we have a gonorrheal infection of the kidney, the organisms must be demonstrated in the pus or tissues. Simmons says that of the 25 cases in the literature up to 1913 in only 15 was the gonococcus actually found. This, we feel, reduces the number of cases considerably, as many other organisms will give rise to symptoms of kidney infection. Sixteen of the cases reported in this group were males, one occurring ten days after the original infection in the urethra. The case reported by Stanton developed nine years after the original gonorrhea. This, we know, must be annoying for a gonorrheal patient to ponder over.

#### AUTHOR'S CASE

There is so little data available for study in the cases reported to date, that

we believe you will be interested in first-hand information of our own case.

The patient was a young white woman, twenty-two years of age, a native of the United States. Her previous family and personal history are of relatively little interest, with one exception: she denied any possible venereal infection.

*Present Illness:* We were called to see this young lady who was a patient in the hospital in September 1928. Two weeks previous to our visit she had had an abortion performed, apparently at about the fourth month of pregnancy. On the following day she developed chills and fever and gradually a mass appeared over the left kidney. When we saw her, the mass was so large that it could be seen as well as felt. The patient was thoroughly septic and her condition was wretched. We suggested a vaginal examination, which for some reason she did not wish; but, by insisting, we finally obtained her consent to a complete observation. Almost before we had entered the vagina, we found a huge pelvic abscess.

It was at once evident that the primary source of infection was not in the kidney but in the lower genital tract. The pelvic abscess was first opened through the vagina, and a large amount of greenish pus was evacuated. Cultures from this material showed gonococci in abundance. Next, in the same sitting, we incised the swelling over the kidney. Upon passing through the muscle planes of the back, found ourselves in a large abscess cavity with the kidney in its center. In fact, the organ was so close to the surface that we saw almost at once that our abscess was connected directly with it. An opening into the kidney was found and cultures were taken from both it and the surrounding areas. All of the cultures and slides showed gonococci.

Further study of this case revealed that this young unmarried woman was probably infected with gonorrhea at the time of her impregnation.

You will say "what are the signs of a gonococcal kidney disease?" There are none whatever that are characteristic. One sees merely the symptoms of a kidney infection or abscess in or around that organ.



# POSTERIOR COLPOTOMY FOR PELVIC INFECTION\*

(FRAENKEL TECHNIC)

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OUR chief interest in pelvic infection is not in its frequency or in its chronic course, but rather in its tendency to recurrence and its close association with sterility and ectopic pregnancy, thus making it one of the most important diseases of the female genital tract. There are three general types of treatment:

1. Radical therapy consisting in laparotomy with removal of a major portion of the female genital tract.

2. The expectant therapy: rest in bed, care of the bowels, diathermy and foreign protein injections.

3. A course between the two, one not quite so radical as the first method and yet making full use of all conservative measures at our disposal.

There are two main objections to the radical form of treatment:

1. Due to the tremendous amount of infiltration and an absence of lines of demarcation of the disease it is frequently necessary to sacrifice a major portion of the female genital tract and as these conditions occur mainly in young adult life, a loss of both ovaries, tubes and part of the uterus makes the patient an invalid for life.

2. The mortality of this process is high and its morbidity very severe.

There are two main objections to the conservative treatment:

1. If it is carried too far, complications such as a rupture of the pus sac into the bowel, or rupture into the general peritoneal cavity followed by general peritonitis with its severe morbidity and occasionally death may occur.

2. Pure conservative therapy requires a long period of hospitalization which, besides the tremendous expense incurred, also

means a distinct monetary loss to the patient due to her loss of earning capacity.

The mortality of the radical procedure being so high and convalescence from the purely conservative treatment so protracted, a path was sought between the two: one which would drain the infiltrated area and shorten the convalescence of the patient, thereby returning her to her economic state in the shortest possible space of time.

For this purpose, posterior colpotomy is an almost ideal method. This procedure has been in vogue for a great many years. Morely<sup>1</sup> states that "according to Bourdon,<sup>2</sup> Callisen<sup>3</sup> (1798) was the first to venture opening a pelvic abscess by the vaginal route. This procedure was copied by Macarn in 1788, who reported 3 cases." Since then, Dumarquay<sup>4</sup> (1857), Chassaignac<sup>5</sup> (1859) and Nonat<sup>6</sup> (1874) in France, Spencer Wells<sup>8</sup> in England, D. W. Brickell<sup>10</sup> (1877), Th. A. Emet<sup>9</sup> (1880) and Pryor<sup>13</sup> (1899) in America, all performed posterior colpotomy for the drainage of collections of pus in the cul-de-sac. Pryor even went a step further, opening the cul-de-sac in all pelvic infections where he suspected the possibility of pus forming. D. Warren Brickell<sup>10</sup> stated in 1877:

My conviction is that if early operative procedure is once admitted to be proper (and for this I strenuously contend), the operation per vaginam will take complete precedence. I am satisfied that it must be rarely exceptional to find the purulent collection early "pointing" or inviting the knife or trocar towards the external surface. Long before this stage and when the abscess is comparatively small, puncture per vaginam will promptly relieve. There is a positive demand to remove serum as to remove pus; nevertheless it would be almost a hopeless task to convince any con-

\*Submitted for publication May 23, 1930.

siderable number of surgeons to resort to such practice without practical illustrations to support the theory.

vagina, and that vaginal fluctuation is definitely present. If the incision is too small to establish a free drainage, the opening may be enlarged with the aid of a bistouri boutoné.

The indications are practically the same today. Crossen<sup>11</sup> (1923) states: "If a collection of pus can be felt low in the pelvis, open and drain by vaginal incision." Eden and Lockyear<sup>12</sup> (1920) state: "When a cystic swelling forms in the Pouch of Douglas, it should be at once evacuated by posterior colpotomy."

In other words, 2 factors are necessary: (1) the development of a large fluctuating tumor, (2) the fluctuating tumor must present itself on the posterior vaginal wall. These 2 factors have prevented this procedure from being carried out very often because the 2 indications were not always met. One frequently would find a large nonfluctuating mass without the production of any large amount of pus, or in other cases, one would find the large mass remaining high with only slight evidence of pointing toward the vagina. Posterior colpotomy in these cases presented difficulties in technic, time consumption, inability of finding the pus,

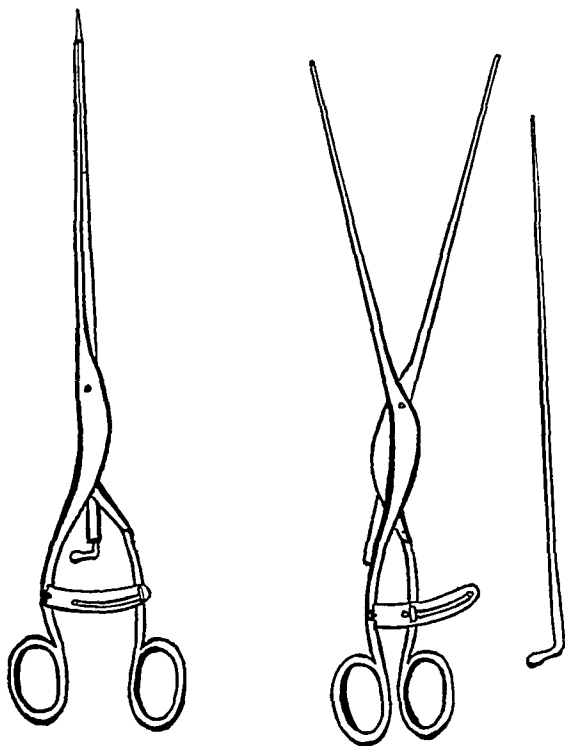


FIG. 1. Fraenkel instrument, showing trochar cannula and spreading blades.

Chassaignac<sup>5</sup> in 1859 gave the following indications for posterior vaginal drainage:

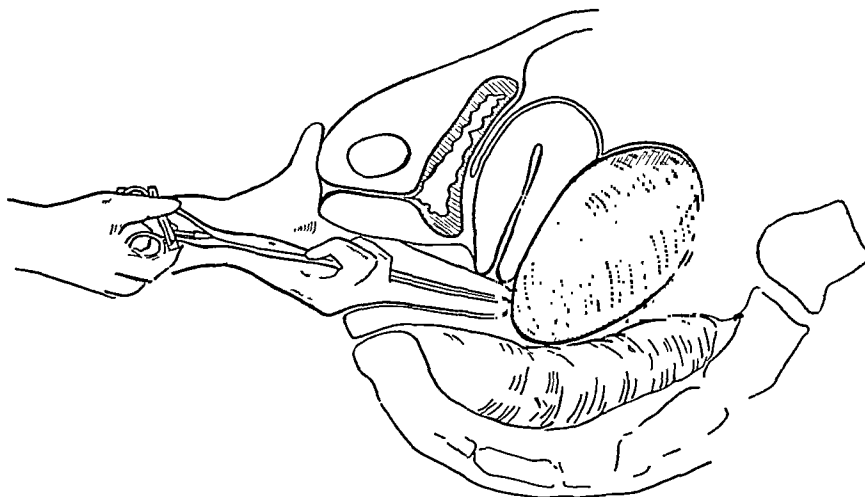


FIG. 2. Instrument passed along middle and index finger of left hand until it strikes posterior cul-de-sac behind cervix.

When an abscess is formed, one establishes the free escape of pus with a bistouri. In order to establish drainage, one must be sure that the abscess points in the direction of the

possibility of perforating the adjacent viscera. Hence the procedure, although a good one, has gradually fallen into disrepute.



In 1924, L. Fraenkel<sup>14</sup> of Breslau, described an instrument for the rapid and accurate drainage of pelvic exudates. The blades apart, one would widen the incision. The Fraenkel instrument is an excellent

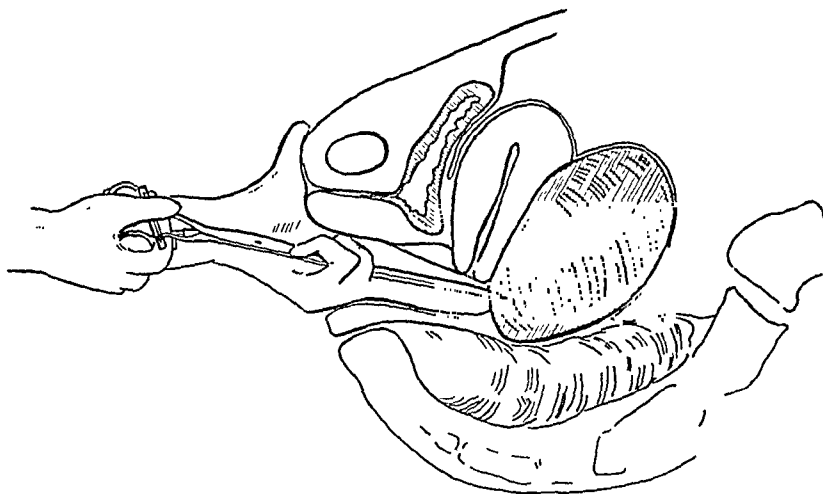


FIG. 3. Trochar pushed forward by index finger of right hand until instrument is fixed in place.

This instrument is built on the plan of a glove stretcher dilator and a trocar cannula (Fig. 1). This principle is not entirely new as Nonat in 1860 described an instrument which he called a trocar-lanceola. His

combination of the trocar-cannula and spreading blade principles.

The technic of posterior colpotomy with this instrument is easily mastered and the entire procedure can be carried out under

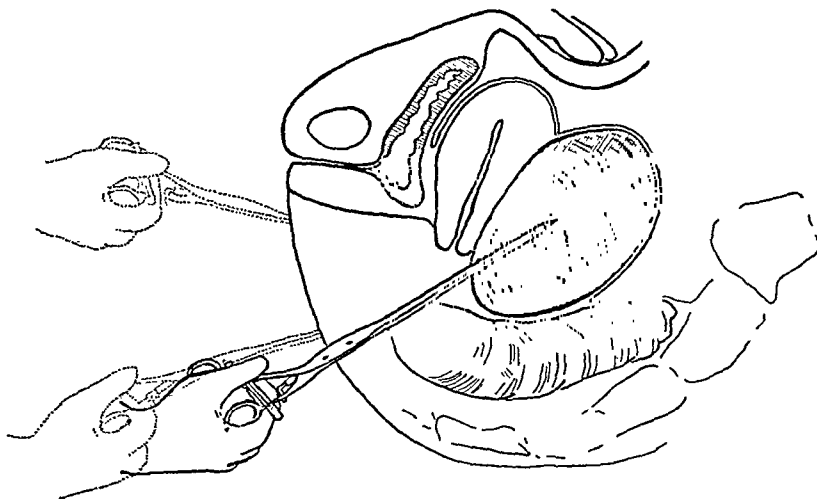


FIG. 4. Handle of instrument now depressed as far as possible and instrument pushed forward towards center of mass, using hand on abdomen as guide. Trochar is withdrawn to see if pus flows through cannula; if pus is obtained handle is then closed, thus opening blades and tearing hole in cul-de-sac.

instrument combined the knife with the trocar. M. Chaput used an instrument called a pince-trocar in a straight and curved model. The characteristics of his instrument were that its blades were sharp, to puncture the mass, and on spreading

the lightest anesthesia. The index and middle fingers of the left hand are introduced into the vagina until they reach the posterior lip of the cervix. The instrument is passed along these two fingers with the trocar inside the cannula (Fig. 2).

When the end of the instrument impinges against the posterior cul-de-sac behind the cervix, the trocar is pushed forward fixing

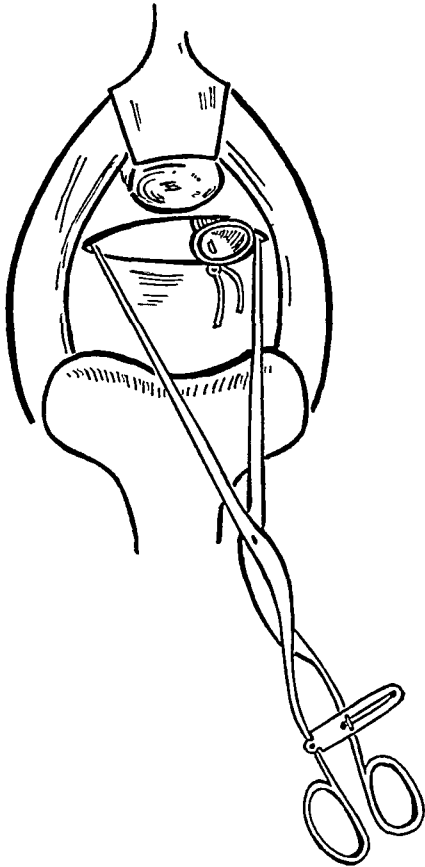


FIG. 5. Hard rubber perforated drain introduced through hole in cul-de-sac and allowed to remain there.

the instrument in place (Fig. 3). The left hand is then withdrawn from the vagina and placed upon the abdominal wall outlining the inflammatory mass. The handle of the instrument is now depressed as far as possible and the instrument pointed toward the center of the mass. It is then pushed into the mass for a distance of about 4 cm. (Fig. 4) or until a loss of resistance is felt. One then knows that the abscess cavity has been entered. The trocar is removed and the contents of the inflammatory mass allowed to escape. A culture and smear are both made from the fluid at this time. The lock on the handle of the instrument is now released and the handle of the instrument closed, thus opening the blades. This bluntly tears through the tissue,

pushing vessels and ureters aside, and thus avoiding the severe bleeding sometimes encountered with the other method of

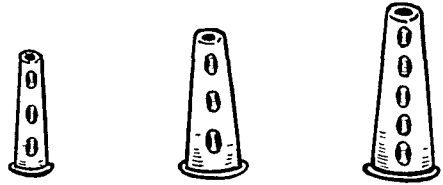


FIG. 6. Three sizes of hard rubber drainage tube showing arrangement of perforation.

colpotomy. When the instrument is opened to its fullest extent, it is again locked with the lock screw and the hard rubber perforated drain is introduced through the hole in the cul-de-sac (Fig. 5). The drain is inserted up to its slightly projecting shoulder. Through one of the perforations in this drain a cord is tied to facilitate its removal. The Fraenkel instrument is then withdrawn and one strip of iodoform gauze is placed in the vagina. The gauze is removed the next day.

The after-treatment of the infection consists in helping the body resorb the exudate and in allowing the exudate to be discharged through the drainage tubes. The associated use of diathermy, hot air treatment, foreign protein therapy and usual supportive measures has given us excellent results.

As soon as the patient's temperature becomes normal, she is allowed out of bed. The drainage tube is never removed before the tenth day; occasionally if the exudate is still present but the temperature is normal, we allow the patient to go home and return to the out-patient department for treatment, removing the tube as late as the sixth week. The advantages of the Fraenkel posterior colpotomy lies in its extraordinary simplicity, the rapidity with which it can be performed and the shortness and lightness of the anesthesia. Fraenkel advocates the use of a hard rubber conical tube because "the concentric tension on the vault of the vagina which, as is known, tends to heal and bring together the cut edges, rapidly

brings compression and clogging of a soft rubber drain. This very centripetal tension of the fornix vaginae holds the hard rubber drainage tube in place." Should another abscess develop on the other side, one may wait a few days and puncture it the same way. If the tube becomes clogged, it is readily removed under vision and another one is inserted.

With the use of this instrument it is not necessary to wait until a tense cystic swelling can be felt in the cul-de-sac. The etiology and location of the inflammatory mass is not of tremendous importance. The important factor is that the mass be encapsulated. In parametric and perimetric infections, we find almost ideal indications for this colpotomy; even in the hard infiltrated masses where no pus is found the colpotomy relieves tension and allows the infectious material to escape. In high intraligamentous infections, where the mass presents itself on the anterior abdominal wall as well as in the pelvis, the colpotomy with extraperitoneal drainage from above will usually clear up the infection.

In those cases where a laparotomy has been performed and a large pyosalpinx, or markedly indurated and infiltrated parametrium is found the opening of which is distinctly contraindicated from above, puncture and drainage of this mass from below under direct vision have given very good results. In the past two years, we have performed this procedure twenty-one times. There have been no complications such as uncontrollable hemorrhage, perforation of a viscus or the development of a fistulous tract from the abscess.

#### CONCLUSIONS

1. With this method we often obtain a quick safe absorption of a pelvic exudate.
2. The mortality is nil.
3. The morbidity of patients with pelvic infection is markedly reduced.
4. Ovaries, tubes and uteri which owing to the infection would be scarified if a laparotomy were performed can be saved and the patient made symptom free.
5. It can make cases which at first seem inoperable, operable and may bring about the conservation of the pelvic organs.

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# THE TRAUMATIZED KIDNEY

## MEASURING THE PERCENTAGE OF DISABILITY\*

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**A**FTER a complete search of the literature for the past ten years I find that little or nothing has been done in the matter of checking up the after-effects of renal injury. It has seemed sufficient to most observers and urologists to be quite satisfied if a patient with a bleeding kidney from traumatism ceases to show hematuria in a fairly satisfactory length of time and is discharged without inquiring to any extent into the exact amount of damage accrued. The coming of industrial-accident boards and commissions with the universal compensation insurance at present in vogue, the damage suits attendant upon automobile and other accidents, not only will now create an incentive to the study of the after-effects of injuries to the kidney but will force upon the medical profession the necessity of being able to report the exact percentage of loss of function.

I have been able to find only 4 cases in the literature to date where the functional end-results of renal injury have been studied.

Shupe reports the case of a young man who fell 20 ft., hitting his back in the descent and landing on his feet on a hard pavement. He complained at once of renal colic and showed a slight tenderness in palpation of the left kidney. There was very little shock but considerable blood in the urine. His treatment consisted of rest in bed. In two days there was no macroscopical blood and in one week it had disappeared when examined by the microscope. Two weeks afterwards cystoscopy was done and both kidneys found to be functioning normally.

Wesson reports 3 cases, one an eight-year old boy, run over by an automobile. There was right iliac fracture and crushing of the second and fourth lumbar vertebrae. There was hematuria for a few days and, after two

months had elapsed, a swelling in the right side developed. This was incised and a large amount of clear fluid containing urea was evacuated. Cystoscopy and functional tests at this time showed both kidneys to be normal.

A man, forty-one, developed a large swelling on the left side one month after being struck by a car rail at that point. The swelling was opened, and about a gallon of urine drained. At this time cystoscopy showed no urine from the left kidney. One month later, after healing of the sinus, the functional output revealed a 50 per cent lessening from the left kidney as compared with the right but neither casts nor evidence of infection.

A man, forty-five, fell 25 ft. and struck on the right side, breaking several ribs. Hematuria lasted for thirty-one days. At the end of this time cystoscopy and functional tests showed a 50 per cent reduction from the right kidney. Re-examination after one year by cystoscope and pyelogram revealed the upper calyx replaced by scar tissue, the surviving renal portion being entirely normal and functioning the same 50 per cent.

My own personal experience has to do with 12 cases.

**CASE I.** Male, aged thirty-three, with a history of injury to the right side, accompanied by pain and hematuria, four years previously. Patient now enters the hospital complaining of frequent attacks of soreness and pain in the right side. Cystoscopic and roentgenological examination reveals an intensive pyuria, an absolute loss of function of the right kidney, a large mass of irregular shadows in the right renal area, and by pyelogram an immense calculus pyonephrosis. That this condition is a result of the kidney rupture is apparent, because at the time of injury a roentgenogram showed no shadow in the right renal area.

**CASE II.** Female, aged thirty, referred by an attorney for examination relative to a suit for damages. Patient received an injury to the right kidney two years ago, characterized

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by hematuria lasting three weeks with pain and tenderness. These symptoms were followed by chills and fever and a diagnosis was made of pyelitis of the right kidney on account of the symptoms and the presence of pus in the urine. Patient still complains of pain and pyuria and has started suit for damages. My cystoscopic and roentgenological examination revealed the urine from the bladder and both kidneys to be free from pus; the renal functional test showed an equal and normal output from both kidneys and the pyelogram revealed a normal right renal pelvis.

CASE III. Male, aged thirty-eight, referred by attorney for examination. One and a half years ago, after unusual muscular exertion, he complained of extreme pain in the right side and hematuria for four days. At this time he states that he has severe pain in the back, becoming agonizing when bending over. He walks in a stiffened upright position when conscious of observation. When observed without his knowledge, he seems to bend fairly freely. Cystoscopic and roentgenological examination revealed a double or fused kidney on the opposite side, an equal and normal functional output from both kidneys, and pyelographic study fails to show any pathological condition of his right kidney.

CASE IV. Boy, aged fourteen, struck by automobile, evident injury to the left side and kidney, accompanied by fairly severe hematuria which gradually let up but continued for twenty-one days. Two months afterwards examination revealed the urine microscopically free of blood or pus and by cystoscope both the kidneys were found to be functioning equally and normally.

CASE V. Male, aged twenty-eight, painter, fell 20 ft. from scaffold, striking on his back; complained of severe pain in the right side, and at first urination noticed a considerable amount of blood. A fracture of the twelfth rib is noted on the roentgenogram. This patient was extremely restless and difficult to keep in bed. The physical signs and pain were probably aggravated by the rib fracture. No tumor could be palpated and the patient showed no signs of shock, and although the hematuria was rather severe, vigilant expectant treatment was decided upon. No complication occurred and the patient finally made a good recovery. Four months later he was given a

routine examination which revealed a perfect and equal function from both kidneys.

CASE VI. Female, aged thirty-two, entered the hospital with a history of having been thrown down and kicked in the back by her husband two months previously. At this time she had hematuria and severe pain in the left kidney region. Under rest in bed the hematuria subsided, but the pain continued in a lessened amount; in the last three weeks it has increased again and tenderness is more marked than before. At examination there is marked tenderness in the left costovertebral angle and flank. Cystoscopic and roentgenological study shows a non-functioning calculous pyonephrosis of the left kidney, which no doubt antedated the injury. Incision of the loin revealed a good sized perinephritic abscess which was drained, and, on account of the rather poor condition of the patient, the nephrectomy was postponed for three weeks.

CASE VII. Female, aged twenty-eight, eight months ago slipped and fell coming out of a building where she was employed. Complained immediately of severe pain on the left side. She was removed to her home in a taxi, and at the second urination considerable blood was noted in the urine. She was removed to a hospital where cystoscopic examination was performed. I am unable to state with certainty whether catheterization of the ureters was likewise accomplished. After expectant treatment for twelve days, the blood entirely disappeared. The side, however, remained sore for a considerable length of time, and two months after the injury she was referred to me for examination. Cystoscopy revealed a normal urine, a normal functional output from the injured side, and the ureteropyelogram delineates a normal ureter and renal pelvis.

CASE VIII. Female, thirty-four, struck by automobile and slightly injured. Complained shortly afterward of pain in the right side and back accompanied by vomiting and malaise. The urine was only slightly reddened after the injury, and blood was not discovered until three days later when her family physician had the urine analyzed. The bleeding was scarcely sufficient to be noticed macroscopically, but the urine continued more or less turbid for two weeks, when a chill accompanied by a rise in temperature to 103°F., and increased pain developed. Under hot applications and

urinary antiseptics, the symptoms subsided in a few days, but the urine at times continued cloudy. A suit for damages having been started, the patient was referred for examination seven weeks after the accident, and at that time the urine contained a considerable number of pus cells, which upon ureteral catheterization were found to proceed from the right renal pelvis. The renal functional test at this time was normal. The pelvis was thoroughly irrigated and an antiseptic instilled. One week later the urine from the bladder and right renal pelvis was found to be free from pus, the renal function again normal, and the ureteropyelogram showing a normal renal pelvis with a slightly dilated ureter. A careful study of the patient's antecedent history reveals that she had been treated for pyelitis of the right kidney during two pregnancies.

In 4 other cases of the usual type of injury, followed by hematuria and evidence of rupture of the kidney, I have been able to make cystoscopic and functional study only going over a period of from one to four years subsequent to the injury. In all four of these there is absolutely no evidence of any deleterious effect upon the functional capacity of the kidney.

#### SUMMARY

After careful perusal of the literature of the past ten years as published by Wesson, Fox, Pisani, Delzell and Harrah, Campbell, Bailey, Graves and Casper, Jefferson, Klingensmith, Marshall, Reese, Shupe, and Young, and from my own

experience, I believe that the result of traumatism to the kidney, as viewed in terms of the percentage loss of functional disability, depends entirely upon the amount and type of destruction of the organ and the presence or absence of complications, particularly infection. My study of those patients injured and not subjected to nephrectomy, who have recovered without the intervention of infection, would surely prove that by far the vast number of ordinary cases of rupture of the kidney recover without any appreciable diminution in the functional ability of the injured kidney. If infection takes place and it is relegated to the renal pelvis alone, there may or may not be alteration in the kidney function. Such cases should be easily curable under the attention of a competent urologist by renal lavage and urinary antisepsis. If infection includes also the parenchyma, then serious results are bound to follow, as pyelonephritis, pyonephrosis, and possible renal calculus are almost sure to develop. As has heretofore been noted, the presence of preexisting renal disease must be taken into consideration in all kidney injuries and it will at times become a difficult problem to satisfy oneself in this matter.

In all events, the exact condition following traumatism to the kidney can be absolutely checked up by the present-day methods of cystoscopic and roentgenological study.



# MEDICAL ASPECTS OF THE TREATMENT OF BENIGN PROSTATIC HYPERTROPHY\*

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THE medical aspects of the treatment of benign hypertrophy of the prostate are summed in the fact that this condition produces obstruction to the urinary tract in elderly men; 85 per cent of the cases demanding operative relief are over sixty years of age. I propose to deal particularly with two phases of the problem: with the evaluation of the resultant functional renal impairment and its treatment, and with some of the complicating factors due to senescent changes in the cardiovascular system.

It seems scarcely necessary to say here that a careful and complete physical examination of the patient should constitute one of the first steps in the treatment of this disease. Such may disclose complicating or coexisting abnormalities (nephritis or heart disease) which must be dealt with as promptly as the urinary obstruction itself.

With hypertrophy of the prostate obstruction of the urinary tract distal to the bladder gradually develops. The anatomical changes which result are well-known. It is necessary here only to draw attention to the fact that the effects of back pressure are bilateral as far as the ureters and kidneys are concerned. The bladder wall hypertrophies, and trabeculation becomes evident; in many cases diverticula appear. The ureters are dilated irregularly; the renal pelves are enlarged and encroach upon the parenchyma of the kidneys. Of the local changes in the kidney so much may be said: in the absence of infection the microscopic alteration in the tubules are far more pronounced than are those in the glomeruli.

The impairment of renal function is generally assumed to be the result of three factors:

1. Back pressure in the urinary tract, even in the early stages, before atrophy of the kidney parenchyma occurs, its powers of elimination are seriously affected.

2. Infection, leading to cystitis, pyelitis, and sometimes pyelonephritis, and

3. Primary renal disease, the result of previous nephritis or of vascular changes in the kidney.

To these should be added a fourth: the functional capacity of the kidney is diminished by any appreciable degree of circulatory insufficiency.

The extent of functional damage may be evaluated by chemical analysis of the blood (it is customary to measure the blood urea) and by the ability of the kidney to eliminate phenolsulphonephthalein. Of the greatest diagnostic and prognostic significance are the successive estimations of the blood urea and of the phthalein excretion after free urinary drainage has been established. Following this, and after the administration of adequate quantities of fluid, the blood urea usually falls and the output of phthalein increases. If, after these procedures, renal function is not improved or restored it must be assumed that irreparable structural damage to the kidney has taken place. Careful physical examination may have revealed the cause of some part of this. Thus, in some cases, the presence of palpably thickened peripheral arteries and narrowed, tortuous arteries in the fundi oculorum, often with patches of exudate in the retinae, indicate widespread vascular disease. It is scarcely to be expected that prostatectomy will cure this state of affairs, although the relief of urinary obstruction and the elimination of infection in the urinary tract, may prolong the patient's life.

\* From the Medical Clinic and the James Buchanan Brady Urological Institute, Johns Hopkins Hospital, Baltimore. Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, April 16, 1930.

Consider briefly the records of two typical cases:

The first, a man of sixty-five, was admitted with complete urinary retention. The blood urea at that time was 100 mg. per cent and the output of phthalein following catheterization was 11 per cent, with an appearance time of fifty minutes. A retention catheter was inserted, and fluid was administered up to 4000 c.c. daily. Four weeks later the blood urea had fallen to normal (30 mg.) and the phthalein excretion had risen to 30 per cent with an appearance time of only eleven minutes. Normal renal function was by no means restored but considerable improvement had occurred.

In the second case, a man of fifty, there was but slight urinary obstruction; the blood urea at the time of admission was 80 mg. per cent and the phthalein excretion 15 per cent. The phthalein appearance time remained at eight minutes for all the observations. The patient had pronounced hypertension, blood pressure 250/140, thickened tortuous arteries, and cardiac hypertrophy. His eye-grounds showed conspicuous papilledema, hemorrhages and huge patches of exudate. Despite the institution of free urinary drainage adequate renal function was never established. The development of myocardial insufficiency, although the patient was digitalized, handicapped the administration of fluid. Two weeks later the patient died. In the meantime the blood urea had risen to 300 mg. per cent and the phthalein had decreased to a mere trace.

In the first case the functional incapacity of the kidneys was due, for the most part, to the obstruction of the urinary tract. In the second it was incidental to generalized vascular disease. Of particular interest is the fact that, although the total excretion of phthalein in the second case was lower than in the first, the dye made its appearance in the urine within the normal time after injection.

To consider only one phase of the effect of age in rendering more difficult the problem of prostatic hypertrophy, any operative procedure upon a patient in the seventh decade of life or thereafter is undertaken in the face of a diminished circulatory reserve.

In the younger individual, in the absence of cardiovascular disease, the circulation, with the aid of its compensatory mechanism, is adequate to meet the most varied demands. With advancing age, however, coincident with degenerative changes in the blood vessels and myocardium, its functional reserve gradually decreases. The arteries become more or less sclerosed; irregular plaques are formed in the intima and may involve the medial coat. Diminution in the caliber of the vessels and impairment of the elasticity of their walls result. The changes in the myocardium are somewhat more varied. In the individual fibers histological alterations, pigmentation, occur which make it possible to distinguish an old fiber from a young one. Furthermore the myocardium may show hypertrophy or fibrosis. The first is the normal response to the increased work required to maintain an adequate blood supply through narrowed, inelastic arteries. Unless the valves are damaged or the resistance in the pulmonary circulation is increased, this enlargement is confined to the left ventricle. Secondly the aorta dilates, chiefly in the region of its base and arch. The second change, myofibrosis, is due to one or both of two factors: First the normal increase in interstitial connective tissue and wasting of muscle fibers, which occur with age, secondly to localized or diffuse muscular degeneration and its replacement by fibrous tissue incident to impairment of the blood supply to the myocardium. The latter is augmented by any sclerotic narrowing of the coronary arteries either at their origin in the aorta or along their course.

Whatever may be the anatomical results of such changes the inevitable physiological effect is an impairment of the capacity of the heart to meet increased demands. The heart's efficiency depends upon the integrity of its metabolism; this presupposes an adequate blood supply to the myocardium in proportion to the load placed upon it. The circulatory requirements under normal conditions can, in the majority of cases, be supplied, but



unusual demands (over-exertion, fever, hypertension etc.) cannot be met without some evidence of circulatory insufficiency.

Physical examination of the senile heart frequently presents the following clinical picture: The impulse is often obscured by overlying emphysematous lung; when visible or palpable it is usually displaced somewhat to the left. The relative cardiac dullness is enlarged, particularly to the left and downward, and the retrosternal dullness, in the first and second interspaces, is widened, corresponding to the dilated aorta. The heart sounds at the apex are distant and feeble, and are often accompanied by a blowing murmur (functional mitral insufficiency). Over the base the aortic second sound may be sharp but, in the absence of hypertension, is not greatly accentuated. More characteristic is a systolic murmur in the second right interspace, sometimes transmitted upward. This is produced, supposedly, either by arteriosclerotic stiffening of the aortic cusps or by the relative disproportion in the diameter of the normal aortic orifice and the dilated arch. The cardiac rhythm may be normal but is often interrupted by ventricular extrasystoles. Rarely auricular fibrillation may be present.

In the absence of myocardial insufficiency such patients present few symptoms referable to the heart. They are conscious of limitation of their capacity for physical work, and occasionally complain of palpitation; this latter symptom is sometimes lacking even in cases showing numerous extrasystoles. As the circulation becomes overtaxed, however, more obvious symptoms develop: fatigue, breathlessness while talking, dyspnea on slight exertion and orthopnea. Finally a small proportion of these patients complain of typical anginal pain. The physical signs of myocardial insufficiency may be present in varying degrees. These include evidence of pulmonary edema, râles at the lung bases, hepatic enlargement, and edema of the extremities.

It has become increasingly apparent that the frequency and severity of post-

operative complications may be materially lessened by adequate preoperative preparation.

*Rest* is a most important measure. Frequency of urination particularly at night may have so interfered with sleep that the patient is well-nigh exhausted. This may be relieved by catheter drainage. Sedatives, luminal or even opiates, should be prescribed as required.

*Diet* is often a perplexing problem. In the acute stages, with nitrogen retention, milk is borne best, (800 to 1000 c.c. daily). Subsequently a more complete diet may be administered. In cases with edema salt should be restricted (1.0 gm. or less). Even in the presence of nitrogen retention it is useless to reduce the protein intake below that amount necessary to maintain the patient in nitrogen equilibrium (50 to 60 gm. per day).

*Fluids.* The impairment of renal function due to obstruction of the urinary tract appears to interfere less with the excretion of water than with that of nitrogenous waste products. To the end that adequate nitrogen excretion may be accomplished as well as to combat the infection in the urinary tract it is often necessary to administer large quantities of fluid to these patients. This constitutes, sometimes, a very vexing problem. If the patient is not already nauseated forcing fluids by mouth may make him so. If signs of circulatory insufficiency are present too large a fluid intake may only make a bad matter worse.

It seems most advisable to determine first whether any degree of circulatory insufficiency exists. If such is the case it is unwise to force fluid at once but better to increase the fluid intake gradually after one or two days' rest and digitalization. In general, too, the administration of fluids by the intravenous route, in elderly patients, is to be undertaken with caution.

When this appears imperative the following method has proved useful. It is similar to that suggested several years ago by Dr. Matas. A silver cannula is inserted into a superficial vein, usually on the foot,

and is tied in place. Through this normal salt solution is injected continuously, regulated by a drop device quite similar to the Murphy drip so that the patient receives not more than 100 to 200 c.c. per hour. In this fashion large amounts of fluid may be given over a period of days and so slowly that the circulation is not embarrassed thereby.

*Digitalis.* As has been so often stated the indication for digitalis is myocardial insufficiency; the routine administration of this drug is not only useless but unwise. It should, however, be given to any patient showing signs of congestive failure, and in adequate quantity, i.e., 1.5 gm. standard leaves per 100 lb. body weight, or an equivalent amount of some standardized preparation. This is best administered in divided doses over a period of forty-eight hours or more, except in cases of acute failure to which it may be given more rapidly. After the maximum therapeutic effect has been obtained digitalis should be continued at 0.1 to 0.2 gm. daily to replace the amount normally excreted. If the patient has received this drug prior to admission digitalis must be administered in smaller doses and a longer period allowed for digitalization in order to avoid intoxication. The development of acute dilatation to which we shall refer presently calls for an increase in digitalis dosage, or, if the patient has not been fully digitalized previously, for strophanthin (0.5 to 1.0 mg. intramuscularly). In cases showing numerous ventricular extrasystoles the combination of digitalis with dionine may often restore the normal rhythm more quickly than does digitalis alone. This is given in capsules (Fol. digitalis 0.1 gm., dionine 0.006 gm.) and continued up to the therapeutic maximum for digitalis.

*Operation.* The circulatory strain resulting directly from an operation is due to one or both of two factors. The first is reflected in a reduction of the vital capacity. The normal vital capacity falls steadily during the sixth and seventh decades of life and thereafter, until at

eighty it is but 45 to 50 per cent that of the normal at thirty years of age. Following an operation, particularly an abdominal operation, this is often still further reduced. The chief circulatory strain may be due to the second of these factors, i.e. the anesthetic. Here the choice is often a nice one. Aside from increasing the frequency of postoperative pulmonary complications, general anesthesia, ether or nitrous oxide, is attended by a degree of anoxemia and by secondary circulatory changes which must be regarded as dangerous in elderly patients. Herein lies the advantage of caudal or of spinal anesthesia. Except in occasional, very apprehensive, patients with symptoms of angina pectoris we have used caudal or epidural anesthesia, injecting 20 c.c. of a 3 per cent solution of procaine into the sacral hiatus. Morphine (16 mg.) is given the night before operation to insure rest and again just before the patient is removed to the operating room.

*Postoperative Treatment.* Digitalis should be continued after operation in doses just sufficient to maintain the therapeutic effect (0.1 to at most 0.2 gm. daily). During the first two postoperative days this is usually best administered by injection, digifoline 1 to 2 c.c. The interference with respiration caused by abdominal distension may sometimes contribute to circulatory failure. This should, therefore, be prevented as far as possible, and vigorously combated as soon as it appears. Certain drugs, and particularly morphine, contribute to distension by relaxing the intestine. Schlesinger's solution and pantopon seem less likely to foster distention and at the same time are efficient sedatives. After prostatectomy any treatment per rectum, enema or passage of rectal tube, is to be avoided on account of danger of embolism. Turpentine stupes, pituitrin or eserine are usually effective in dispelling distension.

One of the most alarming postoperative complications is acute cardiac dilatation. In this condition the myocardium becomes suddenly unable to accomplish an adequate

systolic discharge. Symptoms and signs of circulatory failure rapidly develop, the patient becomes cyanotic, the pulse rapid and thready, the blood pressure falls, the pulse pressure is reduced, pulmonary râles become evident and the liver is engorged. The heart is often demonstrably enlarged, its sounds are feeble, and a gallop rhythm is frequently audible. The cause of dilatation is not always immediately evident. It is theoretically due to an increase in the myocardial load beyond the optimum limit in proportion to its oxygen supply.

The most common causes of this complication are pulmonary embolism and coronary occlusion. The abrupt blocking of a greater or lesser portion of the pulmonary circulation suddenly increases the resistance to the output of the right ventricle. The added anoxemia contributes to the failure of the myocardium. Coronary occlusion, by depriving a portion of the myocardium of its arterial supply, may bring about acute and alarming symptoms of dilatation. If the occlusion involves a large vessel death is the inevitable result. If, however, it occupies one of the terminal branches, compensation may later be restored. Minor coronary occlusion may be attended by symptoms and signs of cardiac dilatation and by moderate fever and leucocytosis.

The patient with acute cardiac dilatation is often conscious, restless and extremely apprehensive. A sedative, usually morphia, should, therefore, be given at once. If the patient has not been previously digitalized this should be accomplished as rapidly as possible, best of all with strophanthin. The fall in blood pressure observed in such cases is due less to peripheral vascular relaxation than to the diminished systolic output of the heart. The administration of adrenalin in an attempt to raise the blood pressure by constricting the peripheral vascular bed may only increase the load upon an already overburdened ventricle. The use of caffeine (0.2 to 0.3 gm.) to stimulate

systolic contraction of the myocardium is rather more logical.

When is the patient to be considered ready for operation? This must obviously be decided for each case individually and by the urologist and internist in consultation. More important than the patient's condition upon admission is the degree and rate of his improvement under treatment. As stated previously following the establishment of free urinary drainage and the administration of adequate amounts of fluid, the blood urea usually falls and the phthalein excretion rises. It is well to postpone operation as long as this improvement increases. And yet, in many cases, after a temporary improvement the infection in the urinary tract tends to increase with catheter drainage. To delay too long may, therefore, undo some of the good which has been done. From the point of view of the circulation the return of circulatory compensation should be awaited before operation is attempted. The problem consists in picking the point of maximum improvement for each case.

#### SUMMARY

The importance of a careful and complete physical examination of the patient suffering from benign hypertrophy of the prostate is emphasized. Generalized vascular disease may play no small part in the renal insufficiency so often encountered in these patients.

Many of the medical problems of hypertrophy of the prostate have to do with the anatomical and physiological changes which occur with advancing age. Among them the alteration in the cardiovascular system are most significant.

The preoperative and postoperative treatment of this condition is discussed from a medical standpoint.

The author desired to express his appreciation to Dr. Hugh H. Young for permission to follow these cases on his service, and to acknowledge with thanks the assistance of the staff of the Brady Urological Institute.

# PROSTATIC NEOPLASMS

## THEIR DIAGNOSIS BY NEEDLE PUNCTURE AND ASPIRATION\*

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THE use of some form of needle or trocar for obtaining biopsy specimens is not new. Goeller in 1920 devised a

expert mechanic. We have used the trocar and have also attempted several modifications with more or less the same results.

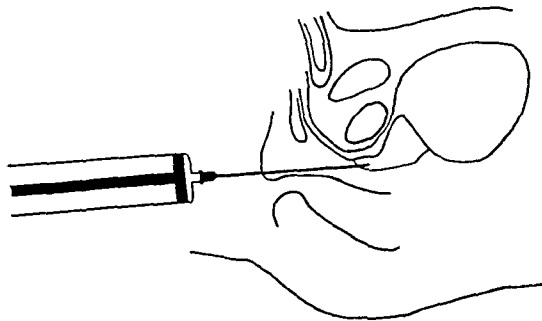


FIG. 1. Prostate in sagittal section showing needle and syringe in first position. Note point of needle just within capsule of prostate and syringe closed.

trocar with a spiral cutting tip for securing tissue from the prostate.<sup>1</sup> Mixer some thirty years ago and more recently Ward,<sup>2</sup> Guthrie<sup>3</sup> and Forkner<sup>4</sup> have devised trocars and needles for special purposes admirably adapted for securing tissue from the various sites in which they were especi-

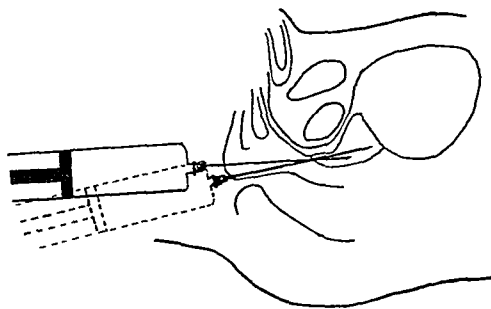


FIG. 3. Syringe in solid outline in third position, withdrawn about 0.5 to 1 cm. from position in Figure 2; suction maintained. In dotted outline, syringe is again advanced but at a different angle in order to cut off plug of tissue in bore of needle. Suction maintained.

Since 1926 Martin and Ellis<sup>5</sup> have employed aspiration with an ordinary 18 gauge needle attached to a record syringe. Martin has consistently applied the method to the general field of tumor diag-

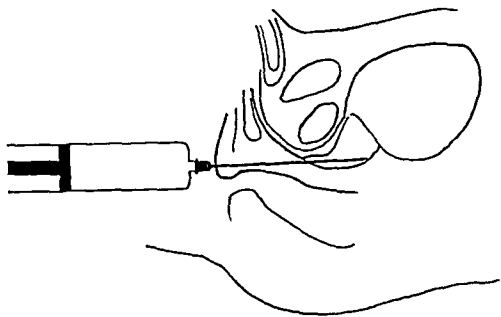


FIG. 2. Plunger of syringe held out as needle is advanced in straight line through suspected prostatic tissue.

ally interested. The Goeller trocar or prostatic screw as it is sometimes called has been in use both at the Memorial Hospital and the New York Hospital since its invention. In our hands its use has proved difficult. It is successful in obtaining tissue from the prostate in about 30 per cent of the cases to which it is applied.<sup>1</sup> To keep the instrument sharp and serviceable requires the services of an

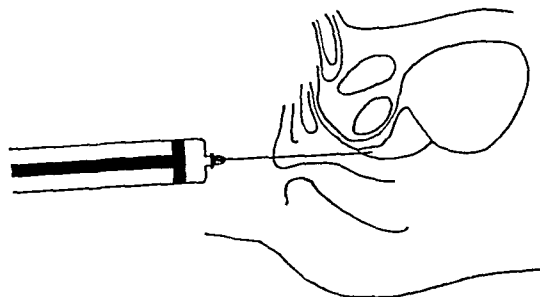


FIG. 4. Needle withdrawn to prostatic capsule. Syringe allowed to equalize slowly. Disconnect needle from syringe and quickly withdraw needle.

nosis at the Memorial Hospital, while Ellis has developed a rapid technic for staining the specimens obtained. Their methods and experience in 65 cases are carefully detailed elsewhere and need no repetition here. At their suggestion we have applied the technic to the diagnosis of prostatic tumors with results so satisfactory that we have abandoned previous methods.

\* From the Guggenheim Urological Fund, Memorial Hospital, New York. Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, May 21, 1930.

## ADVANTAGES AND INDICATIONS

The advantages of such a method of dealing with prostatic lesions are numerous.

use of too short a needle in fat individuals with deep perinei. We find however that with strict adherence to the technic about

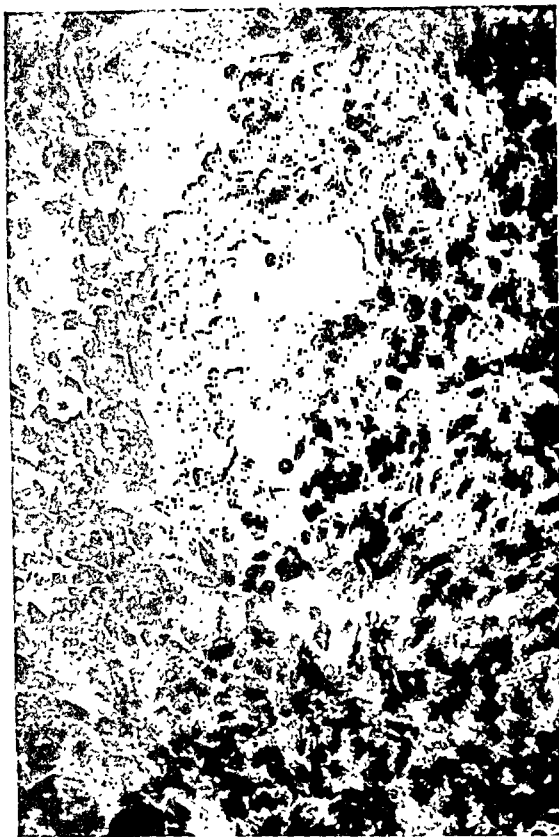


FIG. 5. Carcinoma of prostate. Aspiration biopsy from papillary malignant cyst.

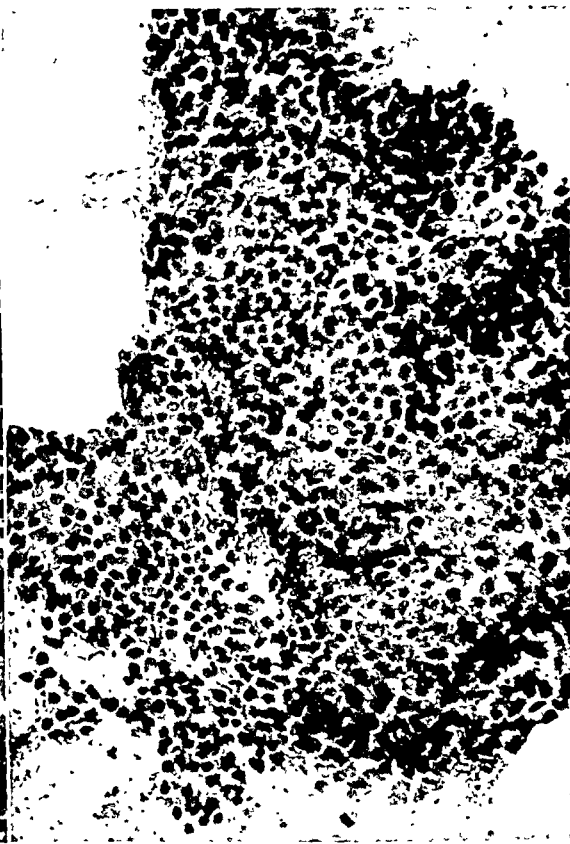


FIG. 6. Small cell carcinoma of prostate. Aspiration biopsy from solitary 2 cm. nodule. Early case.

The paraphernalia required are to be found in any hospital ward or clinic, readily available for impromptu use. The method is readily accepted by the patient without question, as little time and no extensive preparation are necessary. A much higher percentage of success is obtainable than with any previous method. In our hands 70 per cent of aspirations done succeeded in securing demonstrable tissue from the prostate for examination. Some failures will be occasioned by attempts to aspirate tissue from fibrotic myomata or adenomata and from neoplasms which have been heavily radiated. Some early failures were due to the use of a dull needle; we now sharpen the needle after each aspiration. Some more recent failures were due to the

to be described and observation of these details we become more uniformly successful. As to the dangers, Martin in five years' experience failed to find the clinical setting of any case essentially altered by the procedure. The trauma of a single puncture of the tumor wall by an 18 gauge needle may be considered negligible. As far as the prostate is concerned we have yet to see any ill effects in a series of very carefully observed cases. The chief field of usefulness of the procedure lies in the differential diagnosis of the early or doubtful case. We do not use the method where a larger specimen is to be obtained by surgical means. An interesting use of the procedure was made in 2 cases where a metastatic adenocarcinoma of the lung had been

proved by aspiration. Search for the primary growth in both instances was rewarded when aspiration showed adeno-

the index finger of the left hand in the rectum the needle is now carefully guided to the prostatic capsule avoiding both the



FIG. 7. Carcinoma of prostate. Aspiration biopsy.

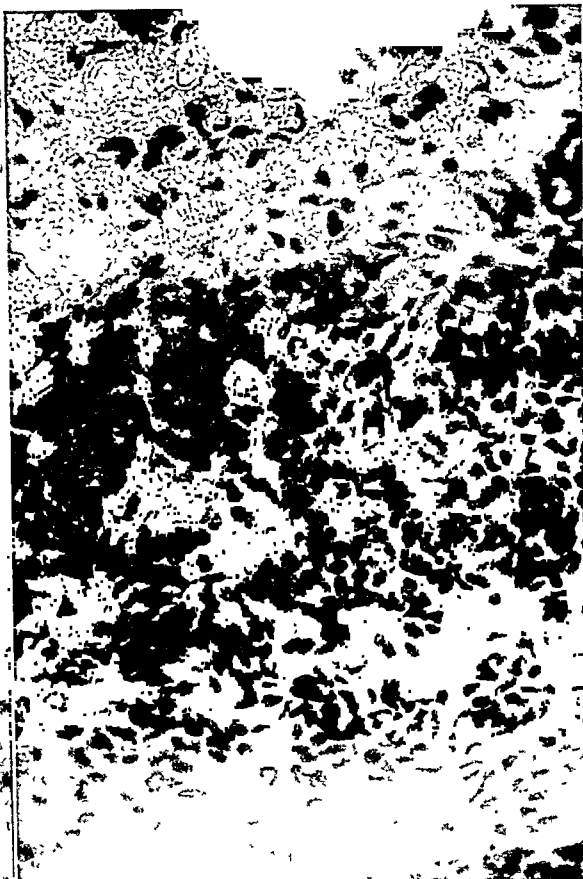


FIG. 8. Carcinoma of prostate. Aspiration biopsy. From highly malignant growth.

carcinoma in the prostate. Neither case had any symptom which would have called the attention of the patient to the prostate.

#### TECHNIC FOR SECURING SPECIMEN

The technic is as follows. The patient is placed in the lithotomy position on the table. The skin of the perineum is cleansed with alcohol. A single wheal of 1 per cent novocaine is raised on the skin just to one side of the median raphe about 1 in. anterior to the anus. This is followed by the infiltration of novocaine down to the prostatic capsule, guided by the index finger of the left hand placed in the rectum. The sterile Record syringe with an 18 gauge needle, 4 to 6 in. long, with long sharp bevel, is now taken in the right hand and inserted through the skin of the perineum avoiding the midline. With

rectal and urethral walls. Figure 1 shows the position of the needle in sagittal section at this juncture and also shows that the insertion up to this point has been accomplished with the plunger of the syringe closed. Now the plunger is drawn out as far as possible, creating a high vacuum in the system, as the needle is advanced in a straight line through the suspected nodule of tissue. This step is illustrated in Figure 2. The result of this step is that a small plug of tissue is sharply cut and drawn up into the needle. In order to cut off the tissue and successfully withdraw it, it is necessary to withdraw the needle about 0.5 to 1 cm. and then advance it again but at a different angle, as illustrated in Figure 3. During this manipulation it should be noted that negative pressure is continu-

ously maintained by holding the plunger of the syringe out. The needle is now withdrawn to the prostatic capsule, the

to smears of tissue from the prostate. The other method is a paraffin embedding method to be utilized when larger amounts



FIG. 9. Carcinoma of prostate. Four year recurrence. Slow growing tumor. Aspiration biopsy.

FIG. 10. Carcinoma of prostate. Aspiration biopsy, early case, small tumor confined to prostate.

pressure in the syringe slowly allowed to equalize (Fig. 4), and the syringe disconnected from the needle. The needle is now quickly withdrawn from the patient, the syringe filled with air and reconnected to the needle. The material in the needle is then slowly and carefully expressed on to a glass slide. It is then smeared with a second glass slide using firm but gentle pressure, as for a blood smear. Care should be taken to get the preparation thin enough for good visualization. Fixation is by gentle heat, after which the specimen is rapidly stained according to the technic described by Ellis and quoted later.

PREPARATION OF THE SPECIMEN

Ellis describes two methods of preparation, one only being generally applicable

of tissue are obtained by the needle. This happens frequently with other tumors but rarely from the prostate. The immediate method is as follows: The fresh tissue fragment on the glass slide is smeared by very firm flat pressure by another glass slide drawn once across. The smeared slide is fixed by gentle heat until warm and dry and is then run through the following technic:

	Minutes
1. Alcohol (95 per cent)	1
2. Water	1
3. Hematoxylin	1
4. Water	1
5. Eosin	1
6. Alcohol (95 per cent)	1½
7. Carbol-xylol	1½
8. Mount with Canada balsam and cover glass.	

The times given may be varied slightly

and it is especially suggested that the staining of the specimen with hematoxylin be followed under the microscope.

cer. Gross morphological structure such as one would find in well cut paraffin sections is of course not to be found. Many

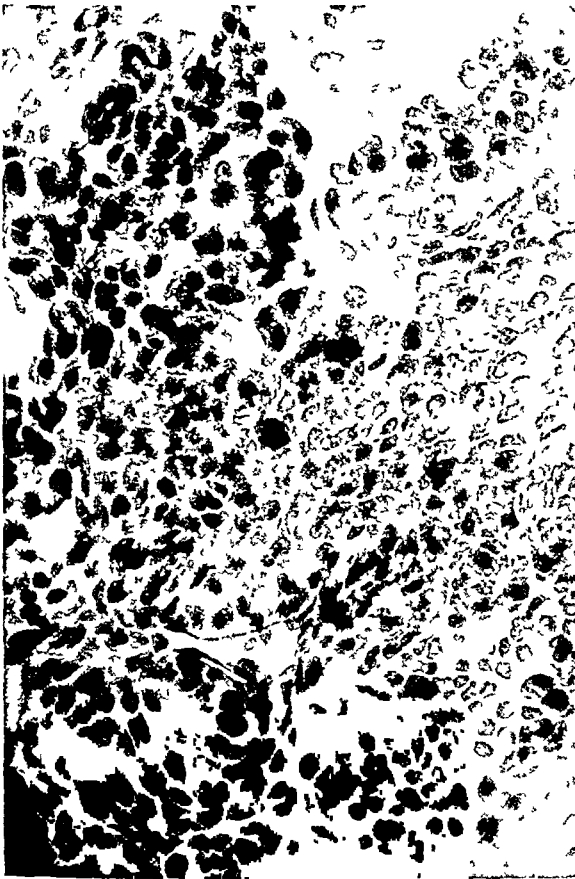


FIG. 11. Carcinoma of prostate. Aspiration biopsy.

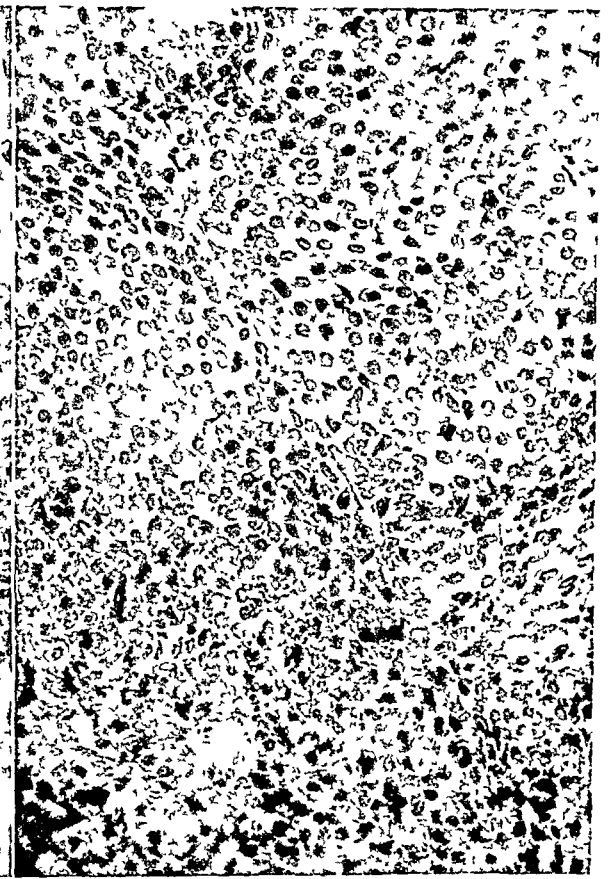


FIG. 12. Carcinoma of prostate. Aspiration biopsy. Small cell tumor.

#### INTERPRETATION OF RESULTS

The interpretation of the smear requires the services of a pathologist fully conversant with the field of tumor diagnosis. He must be associated with a clinician whose clinical interpretation of the facts of the case is accurate and reliable. In these smears careful search reveals small groups of cells having the definite cytological structure and morphological arrangement of cancer. While it would be very unwise to base a diagnosis on a single cell or very small group of cells yet it is easily possible to find enough material scattered throughout the smear, which when carefully studied can lead only to the definite conclusion that the tissue is or is not can-

pathologists would not be willing to hazard a diagnosis on such a small amount of tissue, but we know that with painstaking technic and a pathologist able and willing, a reliable diagnosis of cancer can be made on material obtained as described. Where such conditions do not prevail we would hesitate to recommend the procedure. Under properly organized conditions we feel that the method of biopsy described can be safely and routinely used in the diagnosis of prostatic neoplasms with a higher degree of success and satisfaction than with any method heretofore proposed.

The appended photomicrographs illustrate some of our results. [For references see Author's reprints.]



# ACUTE APPENDICITIS\*

## STATISTICAL REVIEW OF 97 CASES

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THIS study was made with an especial view as to the present-day mortality in cases of acute appendicitis.

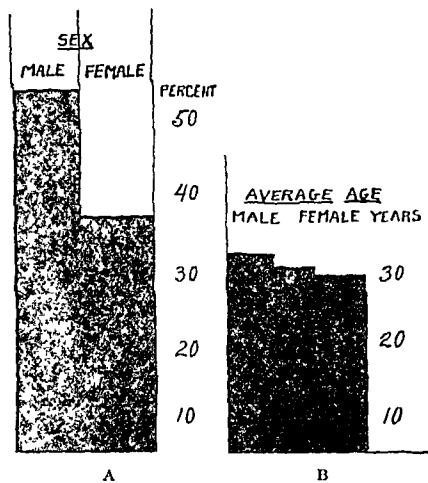


FIG. 1. Age and sex.

It has been my impression for several years, both from my reading and personal association, that the mortality is greater than it was a decade or two earlier.

While the number of cases is small and not large enough to make any very positive statement, on the whole it tends to substantiate the impression.

The study is based upon the cases of acute appendicitis operated upon at the St. Elizabeth Hospital during the year January 1, to December 31, 1929.

In order to arrive at an accurate survey, the following requisites were made essential for each case considered:

1. A complete and legible history. Physical examination and a provisional diagnosis of acute appendicitis made.

2. The surgeon's and pathologist's final diagnosis must agree, i.e. the case is one of undoubted acute appendicitis.

3. The case must have been uncomplicated by any other abdominal or pelvic pathology.

4. That at the time of survey the case must have been terminated and the chart closed under the heading of surgical cure or surgical death.

Only 97 cases could be found within the year which fully qualified under these four requisites and these cases form the basis of this report.

As regards the *environment*: The operating-room and service are well organized; the percentage of infections during the same year in other types of cases was equal to or even below the usual figures in most hospitals, the last survey of the infections in the hospital being 0.5 per cent for all cases operated upon.

In none of the cases that died was there any question of the responsibility resting upon the operating-room or the nursing personnel.

Seventeen different surgeons operated upon the 97 cases, as follows:

Eight of the operators were classed as men doing surgery exclusively.

Two were surgeons doing some general practice.

Six were primarily general practitioners doing some surgery.

*Sex.* Of the 97 patients:

58 or 59.8 per cent were males.

39 or 40.3 per cent were females.

Sonnenburg in 1000 cases (survey made in 1910) had a percentage of 67 males.

Deaver at about the same time, in 300 cases, found 61 per cent males.

*Age.* The average age of the males was 26.7 years. The average age of the females was 24.55 years. The average combined age was 25.62 years. This survey then is in general accordance with the statistics of larger groups of cases, in that it is primarily a disease of young

\* Read before The Miami Valley Pathological Society, February 14, 1930.

adult life. The youngest patient was ten months of age. The oldest patient was seventy-nine years of age.

of the abdomen. In 80 per cent of the cases it was definitely located in the right lower quadrant.

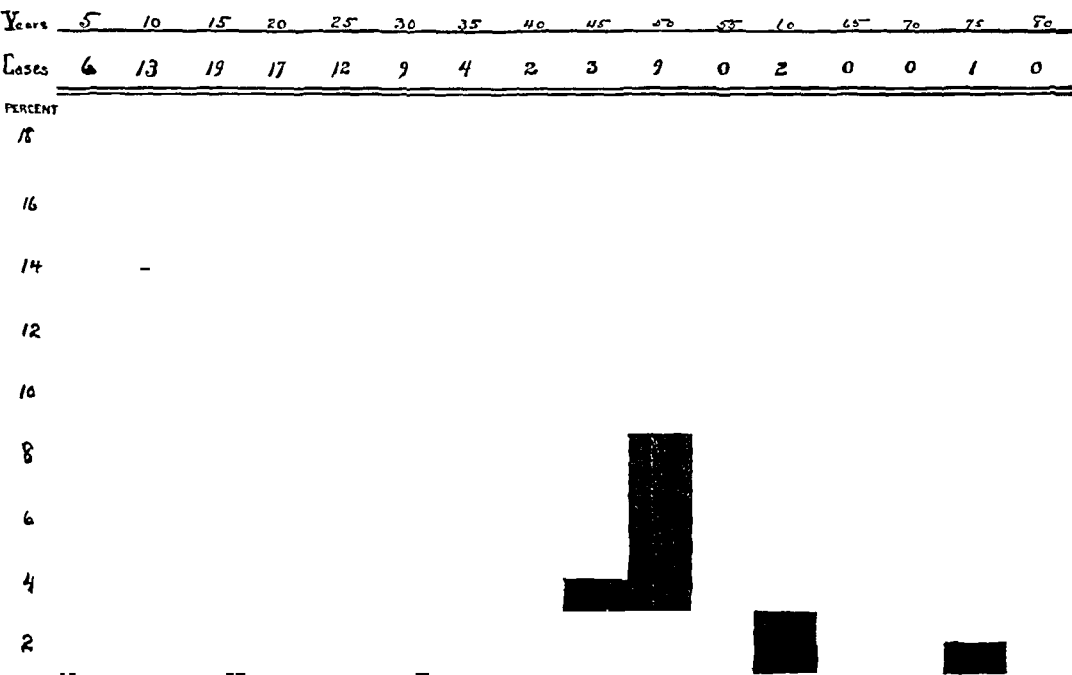


FIG. 1C. Age and sex.

Arranged in five-year periods we have the following:

TABLE I	
Years	Cases
1- 5	6
5-10	13
10-15	19
15-20	17
20-25	12
25-30	9
30-35	4
35-40	2
40-45	3
45-50	9
50-55	0
55-60	2
60-65	0
65-70	0
70-75	0
75-80	1

In this group there was no one recurring etiological factor, with the possibility of an immediate preceding tonsillitis in 3 of the cases under ten years of age.

Symptoms. The one symptom common to all was abdominal pain, generalized at first. This pain in a few hours, from four to six, became more intense in one quadrant

Nausea was the next most frequent symptom, present in 72 per cent of the cases.

Vomiting was present in 50 per cent, occurring only once or twice unless the case was complicated with some degree of peritonitis.

Constipation, from the beginning of the attack at least, was also the rule except in the rare instance where an appendicitis apparently followed hard upon the ingestion of a late hour meal of heavy food.

No case of twenty-four hour duration was entirely afebrile or had a temperature of more than 100 $\frac{2}{5}$ ° F., except in children under ten years of age. After the first twenty-four hours the degree of temperature depended upon the local condition, the degree of tension of the pus, whether an extra-appendicular abscess was forming, and the degree of peritonitis existing.

I would like to say at this point that these cases with one exception were not recurrent cases.

Leucocytosis. Seventy of the 97 cases

had a white blood cell and differential count made after admission to the hospital and just prior to the operation.

Case No. 11848. Male, aged forty-nine, ill seventy-two hours. Perforated appendix and general peritonitis. Appendix removed,

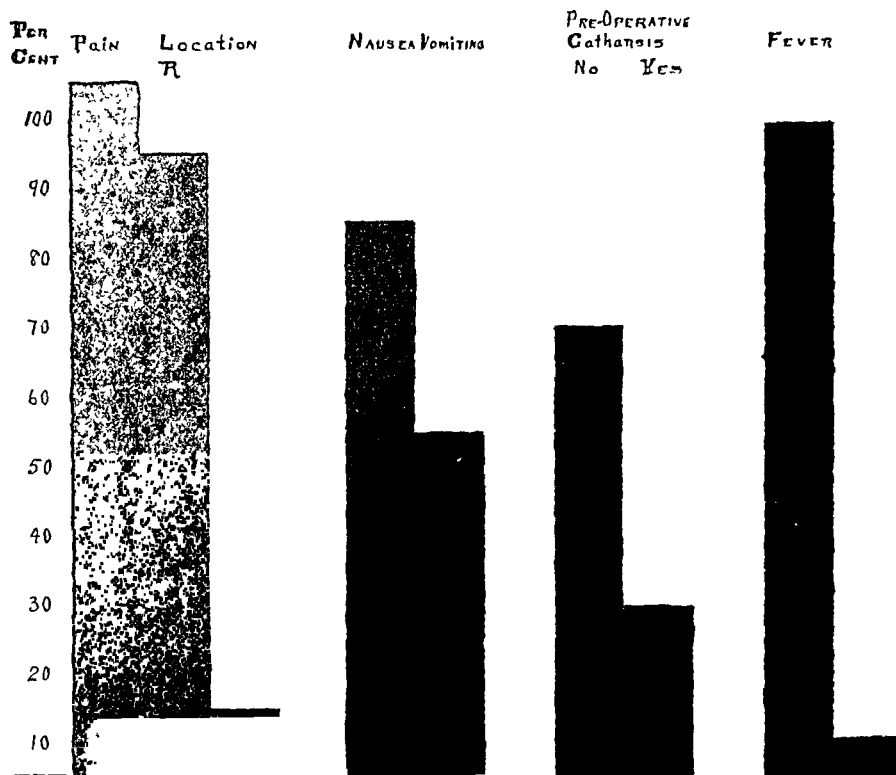


FIG. 2. Symptoms.

TABLE II

Cases	Leucocytes	Percentage
14	5,000-10,000	20
35	10,000-15,000	50
11	15,000-20,000	15.7
8	20,000-25,000	11.4
2	25,000-30,000	2.9

TABLE III

DIFFERENTIAL LEUCOCYTE COUNT

Cases	Polymorphonuclear (per cent)
2	50-55
1	55-60
3	60-65
6	65-70
5	70-75
11	75-80
19	80-85
14	85-90
9	90-95
2	95-100

The two cases having between 50 and 55 per cent leucocytes were:

multiple Penrose drainage, in the hospital forty-two days. Re-opened on the twenty-fifth postoperative day, on account of persistent purulent drainage from abdominal sinus. Fecolith removed. Recovery.

Case No. 4336. Female, aged ten, ill seventy-two hours. Gangrenous appendix, general peritonitis. Slough of appendix removed, Penrose drain to appendiceal stump and right renal fossa, tube stab drainage, midline, for pelvis. No complication. Hospital stay twenty-three days. Recovery.

One case had between 55-60 per cent:

Case No. 4336. Female, aged 7, ill fourteen days. Perforated appendix, general peritonitis. Hospital stay eight days. Died of Peritonitis. 6800 leuc., 58 per cent polys.

Three cases had between 60 and 65:

Case No. 4588. Male, aged one year, ill fourteen days. Perforated appendix, general

peritonitis. Appendix removed and tube drainage. Died three days postoperative of peritonitis. 9800 leuc., 60 per cent polys.

have been published. One by Eggers<sup>2</sup> states the degree of leucocytosis is not an indication of the severity or the extent

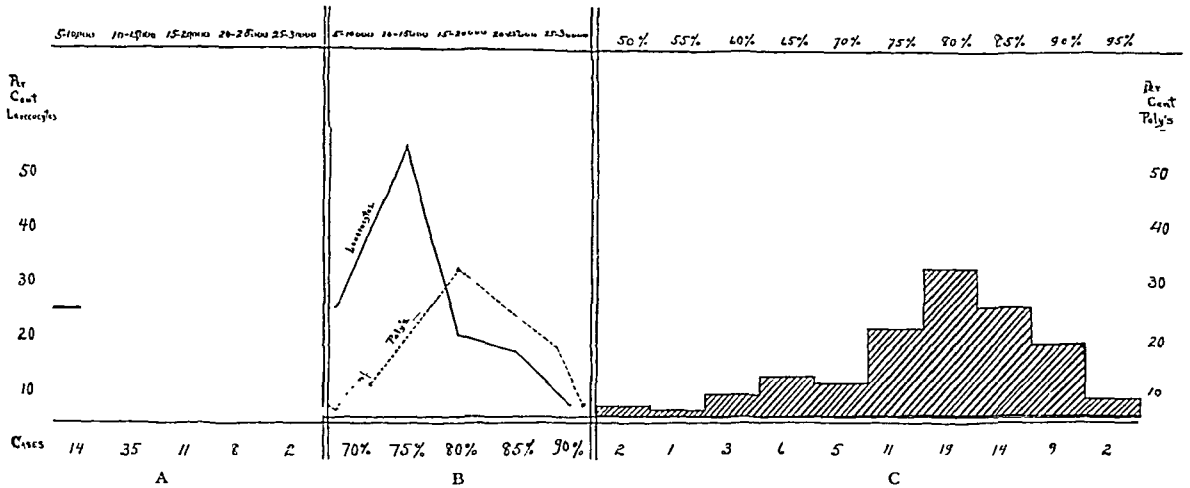


FIG. 3. Blood findings. A. Leucocytes. B. Leucocyte and polymorphonuclear leucocyte curve. C. Polymorphonuclear leucocytes.

Case No. 4525. Female, aged thirty, ill twelve days. Perforated appendix, general peritonitis. Appendix removed, tube drainage. Hospital stay fourteen days. Cured. 9000 leuc., 64 per cent polys.

Case No. 3476. Male, aged twelve years, ill seventy-two hours. Acute appendicitis, local peritonitis, confined to right iliac fossa. Appendix removed, Penrose drainage. Hospital stay twenty days. Recovery. 10,000 leuc., 58 per cent polys.

Twenty years ago J. B. Murphy wrote in his classic on Appendicitis:

The percentage of polynuclear cells is an indication of the severity of the infection, but not of the degree of destruction; a high percentage does not denote a bad prognosis, so long as the absolute number of white cells is correspondingly high. A fall in the absolute number of polynuclears with a coincident decrease of the total percentage of leucocytes shows a decline in the infection. A sudden fall in the absolute number of polymorphonuclears, with a very small decline or perhaps a slight percentage of white cells, is of unfavorable prognostic import. A very unfavorable sign is a sudden fall in the total number of leucocytes.

For many years, in general, surgeons have taken the views just expressed, but this past year two papers on this subject

of an attack. The simple establishment of a leucocytosis is enough to make a diagnosis of acute appendicitis. The same is true of a differential count.

Hellwig<sup>3</sup> in discussing the leucocyte count in 160 cases writes that the height of the leucocytosis bears no relationship to the severity of acute appendicitis. The white blood cell count does not run parallel to the different stages of the pathological process. The practice of not advising operation in acute appendicitis unless there is a marked increase in the number of leucocytes is dangerous. Appendectomy must not be undertaken nor deferred on the basis of the blood count alone. Leucocytosis is a minor symptom, inconstant and unreliable.

Eight of the 9 fatal cases had a blood count made just prior to operation, as one of the deaths occurred following an early operation for simple catarrhal appendicitis from an intestinal obstruction on the ninth day and happened to be the one case on which no count was made. This one will be put aside for statistical purposes, leaving 8 cases to be considered.

Only 3 had a white blood cell count of below 10,000 and one of these was 9800. Thus of the whole number, 14 cases had total

white cell counts of from 5000 to 1000, with a correspondingly low polymorphonuclear count; of these only 4 cases were fatal.

Group 2. Late cases: over twenty-four hours.

Group 3. Late cases: forty-eight hours,

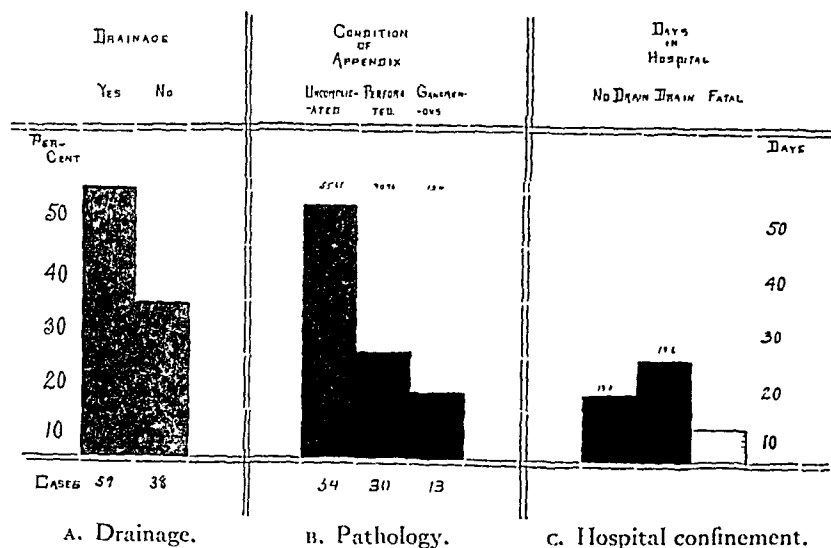


FIG. 4.

As regards the differential count: twelve cases out of the 97 had under 70 per cent poly morphonuclears of the fatal cases, 2 out of 8 had under 70 per cent polymorphonuclears. Ten cases with this count recovered.

This seems to agree with Hillweg's statement that "leucocytosis is a mere symptom, inconstant and unreliable."

**Time.** Now as regards the length of time from onset of pain until operation: In the 97 cases, this averaged 85.4 hours. The fatal cases averaged 198 hours. The average time of the cases that recovered was 79.4 hours. Thus the time element seems to be the most important one factor we have to deal with in considering the mortality of appendicitis.

After the first hours in an appendiceal infection, the pathological process does not necessarily progress at an even time rate and any classification as regards this time must be necessarily arbitrary.

For convenience, I have made a classification which, though crude, is fairly satisfactory for hospital ward use:

Group 1. Early cases: twenty-four hours.

complicated by local peritonitis.

Group 4. Late cases: forty-eight hours, complicated by general peritonitis. According to this classification, we find the following:

Group 1. Early cases (twenty-four hours): 29 cases; 0 deaths.

Group 2. Late cases (over twenty-four hours): 26 cases; 1 death. (On the seventh day due to postoperative intestinal obstruction.)

Group 3. Late cases (over twenty-four hours, complicated by local peritonitis and abscess): 25 cases; 0 deaths.

Group 4. Late cases (over twenty-four hours, complicated by general peritonitis): 17 cases; 8 deaths (42.3 per cent).

In Groups 2 and 3 the condition of the appendix was definitely stated in 43 cases by the surgeon: Appendix perforated in 30 cases; appendix gangrenous in 13 cases.

**Drainage.** All of the late cases with local and general peritonitis were subject to drainage of some kind and degree; in all. In addition in 17 of the 26 late cases in Group 2, drainage was used. Thus all the deaths occurred in late cases with

general peritonitis in which drainage was used except the one in the case of recurrent postoperative intestinal obstruction.

5 cases of 10 years or under (average 7 years).

4 cases 40 to 50 years.

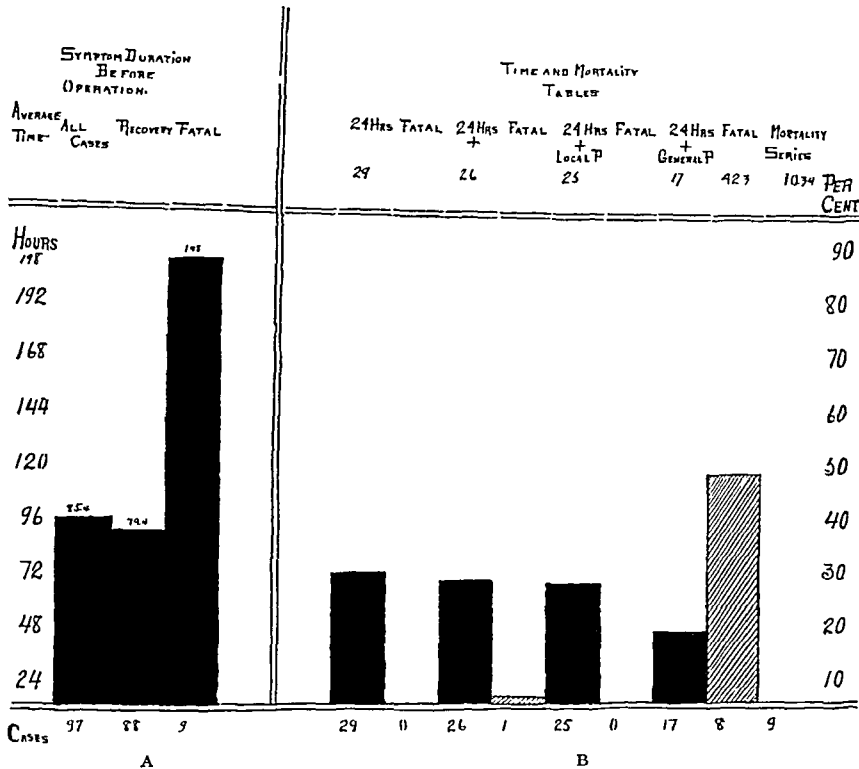


FIG. 5. A. Duration of symptoms. B. Time and mortality.

A variety of drainage means were used, the one most commonly employed being soft rubber tubes, often combined with Penrose rubber wick drainage. Penrose drainage alone was used by a small number of surgeons. The occasional operator always used rubber tubing.

**Hospitalization.** The average stay in the hospital of the drainage cases was 19.6 days; of the undrained cases, 13.1 days. One septic case developed pneumonia with complications which ran a long course. This case was hospitalized 40 days, which brought the average hospitalization up to 13.3 days. The hospital stay was shortest in the fatal cases, averaging 7 days.

## MORTALITY

The total mortality of the series is 10.34 per cent. The total recoveries of the series is 89.66 per cent. The fatal cases may be tabulated:

6 patients were males.

3 patients were females.

Average age of males was 22 years.

Average age of females was 15 years.

In an article by A. M. Willis<sup>4</sup> he states that from 1901 to 1922 the mortality of appendicitis increased almost 31 per cent. His chart illustrating this increase was compiled from the Table of Vital Statistics issued by the U. S. Government; it does not tell what percentage of cases were operated or unoperated on.

What would be the mortality if appendicitis were treated expectantly? This is of course a very difficult question. Fitz of Boston, whose memorable paper on this subject appeared in 1887, gives statistics showing a mortality of 25 per cent. During the 90's at every Medical Meeting, the discussion waged fiercely as to whether to consider appendicitis as the case for the surgeon or the medical man. Only a very few

of the surgeons dared claim that it was a surgical disease; most were content to wait until a tumor formed, then incise and drain.

rest and a suitable diet, in which the mortality was only 16 per cent. These varying forms of treatment may explain

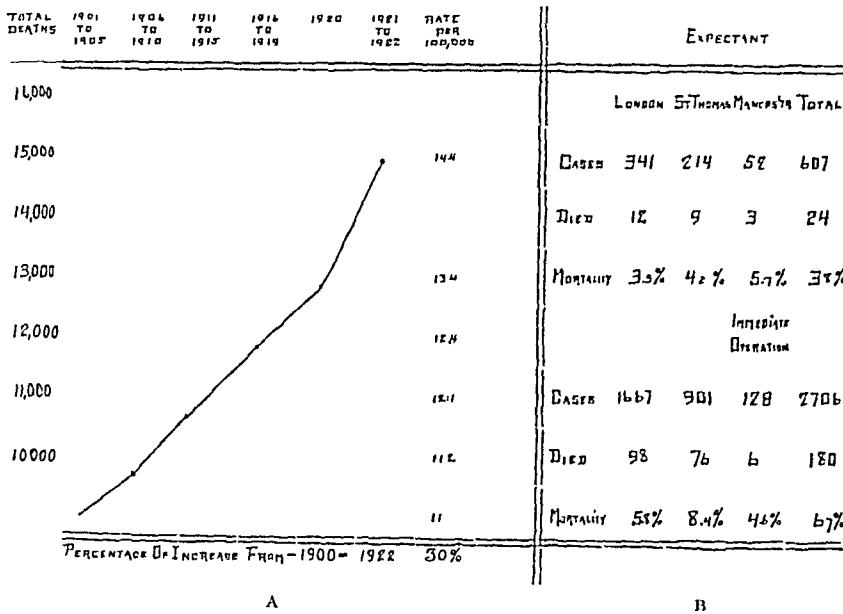


FIG. 6. A. Willis chart of appendicitis mortality. B. English mortality tables.

That the frequency of appendicitis must have been approximately the same in those years is evidenced by tables published in 1893, showing 100 cases of peritonitis due to ruptured appendix out of 1800 post-mortem cases.

Robert Morris, of the "Morris sign" and the "Morris appendix," stated in 1899 that following medical treatment the death rate was at least 25 per cent and that under proper surgical treatment in the beginning of an attack the mortality should not be over 1 per cent. Maurice Richardson, who was one of the most skillful and beloved of Boston surgeons, this same year, however, reported 19 consecutive deaths following operation for appendicitis and questioned whether the surgical rate was not greater than the medical. Ewald in 1891 claimed 90 per cent would recover under medical care.

As a matter of fact, at and before this time there were two views regarding the treatment of appendicitis medically:

(1) By purgatives and injections, which gave in the reported series a mortality of 40 per cent; (2) under tincture of opium,

the wide discrepancies in the claims of the mortality tables.

When I was an interne in 1895 there were still a number of practitioners who treated their appendicitis cases medically unless forced to call in a surgeon because of a walled-off abscess. One of the three surgeons then on the staff, a man of German birth and education, stated repeatedly: "Appendicitis is not so difficult. Opium every day . . . in two weeks, if it is ripe, a cut with a scalpel and . . . it is all over." In many cases his patients survived at least the current attack. The mortality in this hospital must, as I remember, have been about 15 to 18 per cent.

J. B. Murphy claimed on March 2, 1889 he operated upon the first case of appendicitis according to the modern procedure: i.e., deliberately opening the peritoneal cavity in the absence of phlegmon or pronounced induration of the abdominal wall. Murphy in 100 cases from 1889 to 1893 reported his mortality as 11 per cent.

Every death from appendicitis represents an error on the part of some one

connected with the case: the physician, the surgeon, the hospital, the patient or his friends.

In this series the mortality is due to the length of time elapsing from the inception of the symptoms until operation. A physician today should be able to make a diagnosis of appendicitis or at least a surgical condition within twenty-four hours and advise hospital care and operation.

The death rate today is higher than it was two decades ago, although we have learned much in that time. Twenty years ago appendicitis was a live topic. A majority of the profession was converted to the fact that no time should be wasted

in having surgical care. The result was a 2 per cent death rate. Today with so many avenues opening up to claim the medical man's attention, I do not think he is so keen and decided about his views as he was then.

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# EPISIOTOMY AS A MEANS OF PRESERVING

THE PELVIC FLOOR DURING LABOR, WITH A SIMPLE METHOD OF SUTURE\*

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## ANATOMY OF THE PELVIC FLOOR

THE pelvic floor or pelvic diaphragm is a muscle-fibrous partition which closes in the abdominal cavity inferiorly. It closes the space known as the pelvic outlet or inferior strait, which is an oval space bounded anteriorly by the symphysis pubis, posteriorly by the tip of the sacrum and coccyx, and laterally on either side by the rami of the pubes and ischia and the great sacrosciatic ligaments. Just as the abdominal cavity is separated from the thorax by a muscle-fibrous diaphragm, which is pierced by apertures for esophagus, aorta, and vena cava, so is the pelvic outlet closed by a similar diaphragm which is also pierced by three apertures for the passage of the urethra, vagina and rectum. To these three structures, as well as to the bladder, uterus and adnexa above them, the pelvic diaphragm forms the main support and by its integrity prevents bulging, herniation or prolapse of the pelvic and abdominal viscera.

During parturition, however, as the child passes through the vagina, the structures of the pelvic floor are subjected to a great amount of stretching and stress, which in the majority of cases it seems unable to withstand, and which results in more or less separation of its attachments, tearing of its fascia or rupture of its muscular fibers. As soon as the structures are torn the ends separate, forming a gap similar to that which takes place in the severance of a tendon or muscle elsewhere. This results in relaxation or sagging of the pelvic diaphragm with consequent displacement, prolapse or herniation of the organs to which it

gives support and relative amount of disability to the patient, depending on the temperament of the patient, the extent of the damage done and the skill with which it has been repaired.

In order to better indicate the structures involved and the changes which occur as a result of injury during delivery, the following facts concerning the anatomy of the pelvic floor or diaphragm should be kept in mind. This properly includes all the structures which close in the pelvic outlet from the peritoneum above, to the skin below. It consists of two distinct layers of muscles and their fascial coverings.

The inferior layer, derived from the primitive cloaca, includes the deep and superficial transverse perineal muscles, the bulbocavernous, the ischiocavernosus, and the constrictor urethrae. These muscles are for the most part sphincters in action and have little or no supporting function.

The upper layer forms a broad sheet of muscle and fascia consisting of the levatores and the ischiococcygeus muscles on either side, the latter forming the posterior portion of the pelvic diaphragm while the levator ani forms the remaining lateral and anterior portions, except for a short space on the posterior aspect of the symphysis pubis, which is closed in by the triangular ligament. The levator ani is composed of two separate muscles. The external muscle, the iliococcygeus, arises from the rami of the pubis and the pelvic fascia of the white line as far back as the margin of the great sacrosciatic notch. Its fibers are inserted into the sacrum, coccyx, and anococcygeal raphe. The fibers pass from the two sides and decussate

\* Presented as a Thesis to the Fellows of American Association of Obstetricians, Gynaecologists, and Abdominal Surgeons, Memphis, Tenn., Sept., 1929.

with one another in the space between the anus and coccyx. The internal portion of the levator, the pubococcygeus, arises

of the vagina posteriorly and is the portion subjected to the greatest amount of stretching and strain during labor. (Fig.

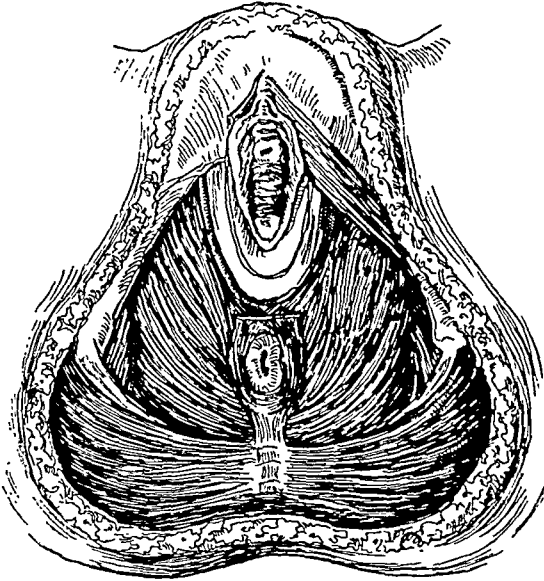


FIG. 1. Showing deep dissection of pelvic diaphragm with horseshoe-shaped margin of levator ani muscle with decussation of anterior fibers in perineal body (fibers of Luschka). Cut edge of rectovesical fascia as it rounds anterior free border of muscle to fuse with anal fascia (which has been removed), is seen. (Redrawn after Kelly.)

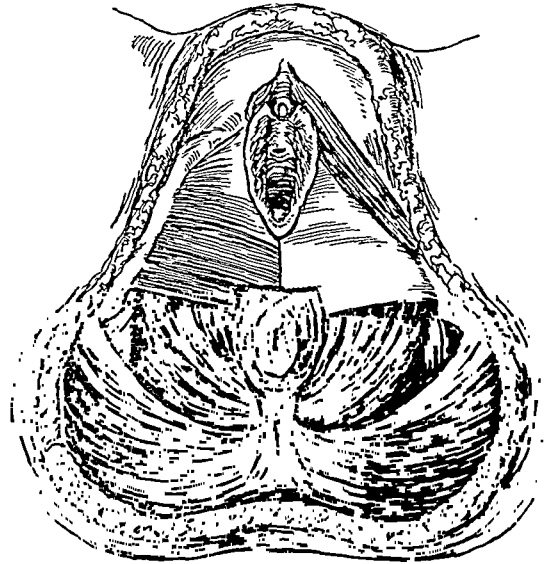


FIG. 2. Urogenital trigone or triangular ligament closing in pelvic outlet anteriorly and pierced by vagina and urethra. (Redrawn after Kelly.)

from the fascia on the back of the symphysis pubis, the pubic rami and from the obturator fascia. The outer and upper third is attached to the sacrum and coccyx; the middle portion, the puborectalis, decussates with its fellow of the opposite side to form a sphincter which slings the rectum to the symphysis pubis and is that portion of the levator most effective in lifting the rectum; the muscle fibers of the innermost third pass behind the vagina without insertion into the vaginal wall to join the longitudinal fibers of the rectum and the external sphincter ani, partly by direct union and partly by decussation with fibers from the opposite side in the space separating the anterior surface of the rectum from the posterior surface of the vagina—the so-called median raphe of the perineum, the muscle-tendinous spot or the central body of the perineum, etc. This internal portion of the levator ani forms, with its fellow of the opposite side, a sling for or constrictor

1.) Injury to the fascia and muscle in this location results in many cases from the overstretching incident to even natural labor and may result in separation of its attachments to the median raphe and rectum, with diastasis, sagging of the anterior rectal wall, and the later development of rectocele.

The levator muscle is covered by fascia, the upper surface by the rectovesical fascia, fascia supradiaphragmatica, or the visceral layer of pelvic fascia which completely closes in the pelvic canal except for the openings of the urethra, vagina and rectum. The lower surface is covered by the anal fascia, or fascia infradiaphragmatica, forming the inner wall of the ischio-rectal fossa and blending with the perineal and anococcygeal raphes. At the free border of the levator ani muscle, as it encircles the vagina laterally and posteriorly, the upper rectovesical layer fuses with the lower anal layer. This forms a fascial sling between the rectum and vagina and as has already been stated, this is the portion subjected to the greatest stress and strain during labor and when

injured is directly concerned with the formation of rectocele.

Closing in the open space between the pubic rami and the inner border of the levator bundles is the urogenital trigone or triangular ligament. It is composed of two strong fascial layers attached in front and at the sides to the pubis and ischiopubic rami as far back as the ischial tuberosities. Posteriorly and laterally it lies below and overlaps the levator muscle and its fascia. Its upper layer blends with the lower layer of the levator fascia. Between the two layers of the triangular ligament, lie the deep transverse perineal and the constrictor urethrae muscles. The urogenital trigone is pierced by the urethra and vagina, to both of which, as well as to the bladder and uterus above them, it gives considerable support, supplementing that of the rectovesical fascia above. Overstretching and laceration of the triangular ligament promote relaxation of the anterior segment of the pelvic floor with the formation of cystocele, urethrocele and prolapse of the anterior vaginal wall. (Fig. 2.)

#### INJURIES TO THE PELVIC FLOOR FROM PARTURITION

For practical purposes therefore as may be seen from the foregoing description, the structures of the pelvic floor may be arbitrarily divided into two segments; an anterior segment closing in the triangular area between the pubic rami composed from above downward of the anterior half of the rectovesical fascia and below the double layer of the triangular ligament; and a posterior segment composed chiefly of the levator ani muscle and the fascia covering its upper and lower surfaces. As the shape and dimensions of the pelvic outlet are subject to wide variations so are these two segments of the pelvic floor subjected to widely different amounts of strain and damage. While in a general way, this may be considered to depend on several factors, such as the size of the child, the

age of the gravida, the elasticity of the soft parts, the amount of scar tissue from previous repairs and the presence or absence of edema of the parts, the two most important factors to be considered are firstly the size of the baby's head and secondly the width of the pubic arch and the transverse diameter of the pelvic outlet. On the one hand, when the pubic arch is wide and the distance between the tubera ischi greater than 8 cm. the presenting parts fit up well between the pubic rami and closely under the symphysis, causing the anterior segment of the pelvic floor to be subjected to the greater amount of stretching and possible injury, with the subsequent development of cystocele, urethrocele, and prolapse of the anterior vaginal wall and bladder; whereas, on the other hand, when the pubic arch is narrow and the transverse diameter of the outlet contracted to less than 8 cm. as is found in the so-called funnel type of pelvis, the presenting part is displaced posteriorly and delivery then takes place more at the expense of the posterior segment of the pelvic floor. In this instance one would expect a greater incidence of injury to the sling of the pubococcygeus bundle of the levator and muscle and its fascia with the subsequent formation of rectocele and furthermore rupture posteriorly of the perineal body, vaginal sulci and occasionally the external sphincter ani and rectal wall.

Tissue reaction to stretching and strain depends to a great extent on the length of time allowed for the stretching to occur, or in other words on the rapidity or slowness with which the force is applied. That the tissues of the modern woman do not well withstand the tension and stretching incident to the average normal labor and that injuries to the pelvic soft parts occur in the great majority of so-called normal labors is a well-known fact. How much greater must they be, however, when the amount of the force is greatly increased in intensity and applied and exerted with an unnatural suddenness

which does not allow the tissues time to stretch as obtains in too rapid delivery with strong bearing down effort on the part of the patient without the relaxation of anesthesia, too rapid manual dilatation or breech extraction, the misuse of pituitrin to hasten delivery and the unnecessary and unskilled use of forceps, especially when they are used to rotate the head from a posterior or transverse to an anterior position. This may result in stripping the levator from its attachments to the pelvic wall or in deep sulcus tears, occasionally laying open the ischiorectal fossa, the fatty tissue of which can be seen in the rent on the side subjected to the greatest amount of strain by rotation. Williams<sup>1</sup> states that injuries to the perineum are of very frequent occurrence, and cannot always be avoided even under the most skillful treatment. Statements as to their frequency vary considerably from those of the physician who has not had a single tear in a 1000 cases, to those who find more or less damage in more than 75 per cent of their primiparous labors. In the former case one would class the attendant as a rather poor observer, because as estimated by Williams,<sup>1</sup> lacerations occur in about 40 per cent of primiparous labors and in about 10 per cent of multiparous labors. These figures undoubtedly are given for lacerations characterized by open wounds where the vaginal mucous membrane or skin is torn along with the underlying structures. Such a laceration is easily recognized and in the majority of cases can be satisfactorily sutured. Much less fortunate are those patients in whom the vaginal integument and skin are not torn but in whom there have been submucous lacerations of the deeper structures of the pelvic floor or separation of the attachments of the levator to the median raphe and rectum. It is impossible to recognize such an injury at the time of labor and these patients are discharged with relaxed supports to the pelvic viscera, greatly enlarged vagina with loose sagging walls and a

relaxed, gaping introitus. Moreover laceration of the anterior segment of the pelvic floor including rectovesical fascia and the triangular ligament with the formation of cystocele is a more or less irreparable injury in a young woman and if repaired is likely to recur during subsequent delivery.

#### SCOPE OF EPISIOTOMY IN PREVENTION OF INJURY

To discharge a patient at the end of the puerperium as well as she was before she became pregnant is the supreme test of the competent obstetric practice and the only one by which our work should be judged. This well-being or fitness applies as well to the integrity of the perineum and pelvic floor, the size of the vagina and the proper supports of the pelvic organs as to the general constitutional health of the mother and child. That this is not accomplished and that the methods of preventing lacerations, and guarding the perineum described in textbooks are inadequate is mutely but forcibly testified to by the large number of women who flock to the gynecological clinics of the country for the repair of injuries incurred at childbirth and who state as the most significant fact in the history of their disability, that they have never been well since the birth of one of their children.

Kelly<sup>2</sup> states that "any considerable injury to the perineum means a laceration of the perineal fascias deep and superficial, the urogenital diaphragm, the levator fascia, and the anterior fibers of the pubococcygeus bundle of the levator ani muscles with consequent retraction of the muscle and separation of the torn ends. In the laceration of long standing there is always atrophy of disease." Pomeroy<sup>3</sup> states:

Every primipara incurs a permanent modification of the pelvic floor in the course of a full-term delivery. In a high percentage of cases this is represented by an open lacerated wound and in nearly all of the others concealed damage to the levator ani muscles and fascia

is acknowledged to occur and to be the factor paramount in the various degrees of subsequent prolapsus uteri, cystocele and rectocele. We, as gynecologists, are devoting years of thought and ingenious labor to planning and executing operations for the repairs of injuries due to childbirth; but so far obstetricians have not faced and accepted a reasonable responsibility for the discovery of a plan to prevent, by sound surgical procedures serious birth divulsion damage to the structures of the pelvic floor. The general attitude toward saving the perineum in the second stage of labor as advocated by textbooks of obstetrics is that little can be done except encouraging gradual dilatation by the avoidance of precipitate expulsion or too rapid extraction in unfavorable positions.

Pomeroy<sup>4</sup> concurs with others in the idea that: "Rending the birth canal to enlarge its caliber is strictly unsurgical." In no other phase of the practice of medicine or surgery are tissues allowed to be bruised, overstretched and rent apart as they are in childbirth, when the same end can be more easily and directly accomplished and more in keeping with surgical principles by cutting the tissues before tearing or divulsion occurs. This may be well accomplished by the operations of episiotomy or perineotomy which is an incision of the posterior vaginal wall and the structures of the perineum and pelvic floor and the restoration of the parts to an integrity similar to that of the nulliparous state after suturing, which is easily performed in a clean-cut, superficial wound. That it accomplishes this end in the majority of cases may be deduced from the description of the anatomy and relations of the structures involved. If the incision is made deeply enough and at the proper time, when the vaginal orifice is dilated to a diameter of about 4 cm. and when the structures of the pelvic floor and perineum, including the sphincter ani, have been well stretched and not overstretched, the incision will sever the following structures, namely, the vaginal mucosa, the united free border of the rectovesical and anal fascias, the

innermost and shortest portion of the pubococcygeus bundle of the levator muscle, especially where it decussates in the space between the rectum and vagina, the posterior portion of the triangular ligament, the superficial perineal muscles, the superficial fascia or fascia of Colles, and the skin. The incision may be made in the midline as in median episiotomy or laterally or bilaterally as in oblique, lateral or bilateral episiotomy. The median incision is to be preferred in the majority of cases because it passes through the stronger instead of the weaker structures, relieves tension symmetrically, and provides more ideal conditions for symmetrical reconstruction by suture. The only assailable point in the claim for superiority of the median incision is the risk of injury to the sphincter ani and of extension backward through the anal and rectal wall. This risk can be greatly minimized by having the anal sphincter thoroughly stretched and paralyzed before making the incision, or when in doubt, as in cases of funnel pelvis or when the child is disproportionately large, by using oblique incision. A relaxed sphincter cut in the midline is usually quite accessible for repair, easily sutured and heals promptly. Episiotomy, by cutting these structures either in the midline by median episiotomy or laterally by cutting through the belly of the muscle on one or both sides as in oblique, lateral or bilateral episiotomy, greatly diminishes the tension on the deeper structures of both the anterior and posterior segments of the pelvic floor, prevents submucous and subcutaneous lacerations and when properly sutured, restores the parts in the majority of cases to their original state.

#### REVIEW OF CASES

In a review of the last 500 consecutive cases of median episiotomy performed by the writer, primary healing of the wound and a satisfactory end-result were obtained in all cases. In the majority of them the integrity of the pelvic floor seemed

intact while in a small number there were slight or moderate degrees of relaxation of either the anterior or posterior segments.

external sphincter and stretching of the rectal wall before making the incision and also by diverting the incision to one or the

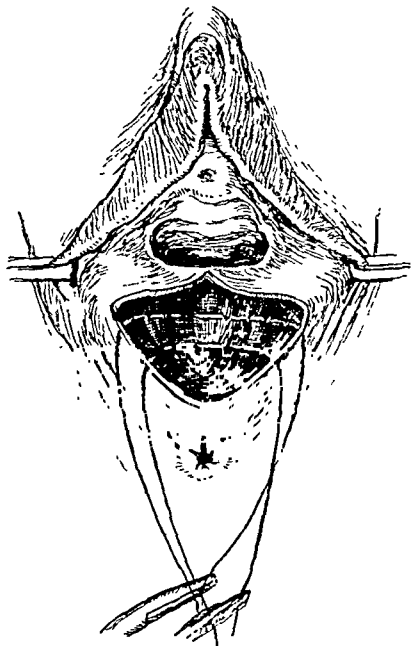


FIG. 3. Median episiotomy wound with sutures buried deeply into retracted severed attachments of levator ani muscle, rectovesical and anal fascias and urogenital trigone.

Six cases showed superficial infections or stitch abscess which did not in any way mar the end-result. Febrile puerperia occurred in 65 cases, 41 of which were attributable to incidental or intercurrent causes as bronchitis, mastitis pyelitis, etc. This gives a total morbidity from all causes of 13 per cent and a corrected morbidity of 4.8 per cent. Considering infection of the wound alone as a cause of morbidity, there were 6 infected wounds in all or 1.2 per cent.

There were 9 cases of bilateral extension up the vaginal sulci and 9 cases of unilateral extension. The majority of these occurred in forceps deliveries either before or after the incision of the perineum. The anterior fibers of external sphincter ani were cut or injured in 15 cases. Extension through the external sphincter occurred in 16 cases and extension through the sphincter and involving the anal margin or rectal wall in 8 cases or 1.6 per cent. With more attention to preliminary dilatation of the

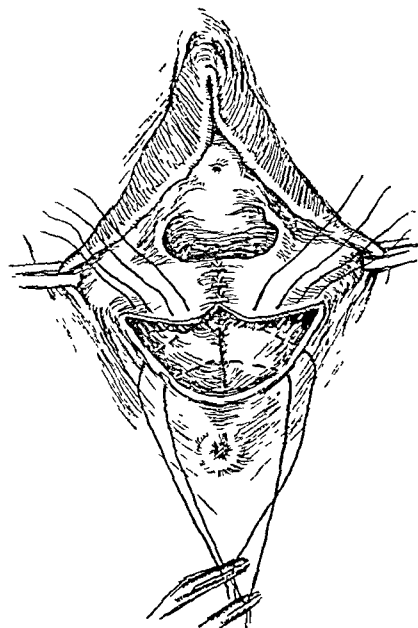


FIG. 4. Vaginal mucosa and underlying fascia closed with interrupted catgut sutures.

other side when extension backward seems imminent, the incidence of sphincter injuries and complete tears can be reduced.

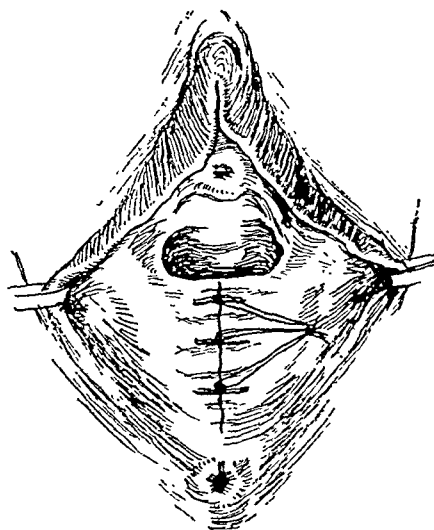


Fig. 5. Skin, superficial fascia and muscles closed with moderately deep silkworm gut sutures.

Where the pubic arch is narrow and the child of considerable size, or when there is edema of the vulva and perineum, it is safer to make an oblique incision one

side of the sphincter ani. Four of the cases with third degree tears had febrile puerperia and one a non-hemolytical streptococcus septicemia, but all healed primarily and in the end made good recoveries. There were 6 cases of phlebitis, 4 of which had pulmonary infarction. There were no deaths in the series.

Old lacerations were repaired through the episiotomy wound in 67 cases, second episiotomy on the same patient at a subsequent delivery in 75 cases, 3 episiotomies on the same patient in 11 cases and 4 episiotomies with same patient in 4 cases. Four patients complained of tenderness in the region of the perineum for several months after delivery but otherwise the results seemed almost uniformly good.

#### A SIMPLE TECHNIC FOR REPAIR

The wound is usually sutured immediately after delivery of the child while the patient is still anesthetized and before separation of the placenta has taken place. No ill effects from delivery of the placenta after the sutures have been placed and tied have been noted.

The introitus is retracted on either side by a Gelpi retractor or tenacula or sutures held by an assistant. Two or three sutures of twenty-day catgut are then placed deeply in the tissues of the deeper plane which should include the severed attach-

ments of the levator bundles with its fascia and urogenital trigone. The sutures are inserted deeply to bring back the structures, which have retracted as a result of their own elasticity, and are introduced at right angles to the course of the muscle fibers and fascial planes. (Fig. 3.) The sutures are clamped and left long to facilitate closure of the vaginal mucosa. This is done with interrupted or submucous catgut sutures including the fascial plane beneath the mucosa. (Fig. 4) The deep buried sutures are then tied and the skin of the superficial muscles and fascia are closed with interrupted silkworm gut. (Fig. 5.)

#### CONCLUSIONS

1. More or less damage to the pelvic floor is caused by delivery in the majority of women.
2. Episiotomy affords an efficient means of lessening the extent and ill effects of this damage.
3. In the proper environment, episiotomy does not seem to increase the morbidity or risk of delivery.

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# AN ADJUSTABLE EXTENSION FOR FRACTURES

## OF THE UPPER THIRD OF THE FEMUR\*

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AS may be noted in the accompanying photographs the adjustable extension for fractures of the upper

himself has a fair amount of freedom facilitating bedside care considerably. Passive motion may be instituted early with-



FIG. 1. Fractured neck of femur. Rear view of extension showing how elevation and abduction are maintained. Dotted line indicates circle of tension or circumference within which tension may be applied.

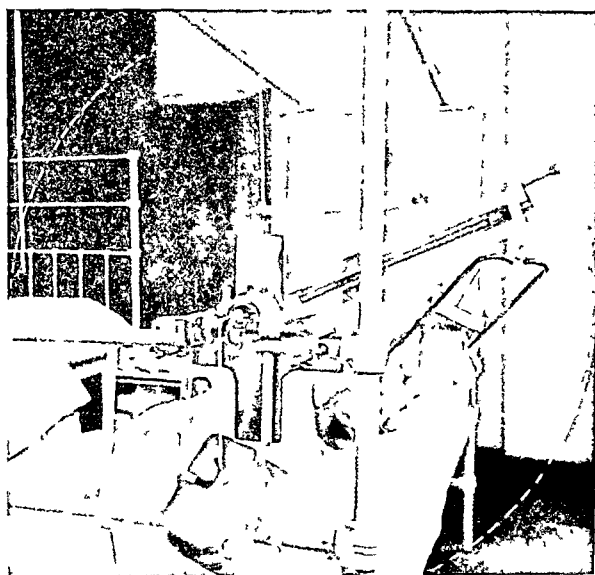


FIG. 2. Rear view of extension.

third of the femur consists essentially of two parts, a stationary plate which is readily attached to any bed simply by the quick turning of two clamps, and a movable arm which describes a circle on which arm a pulley travels throughout its length.

The extension is adjustable in all directions so that the part under tension may be placed in any position at any time without altering the amount or the line of tension desired. The fractured extremity may gradually be placed in the position of elevation and extreme abduction. Daily dressings, more particularly of the under surfaces, are readily accomplished. Decubitus sores are easy to approach. The patient

out danger of the fractured fragments over-riding.

The finest of adjustments obtainable with this device permits the most careful placing from time to time of fractured parts, with or without roentgenological aid. Degrees of angulation, inches and centimeters are noted on the instrument. Although this device has been found particularly adaptable in fractures of the upper third of the femur, it is also ideal for the treatment of other fractures, dislocations, sciatica or any other conditions requiring the application of extension.

Sixty cases of fractures of the upper third of the femur have been treated successfully at the Albany Hospital<sup>1</sup> with this device.

<sup>1</sup> Service of Dr. Arthur Elting

\* Submitted for publication June 3, 1930.



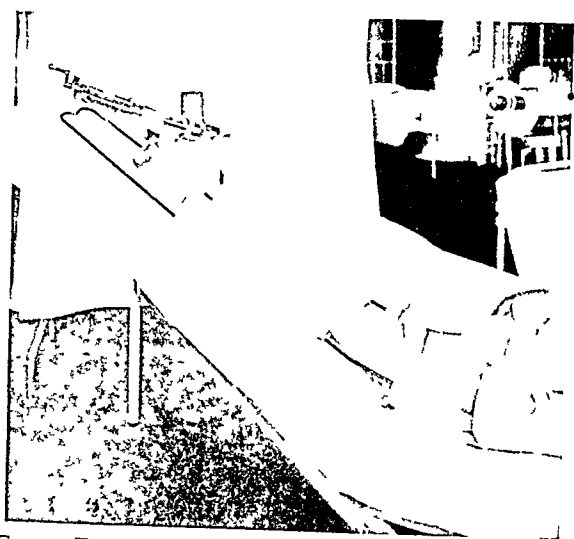


FIG. 3. Front view of extension. Thomas splint in use.

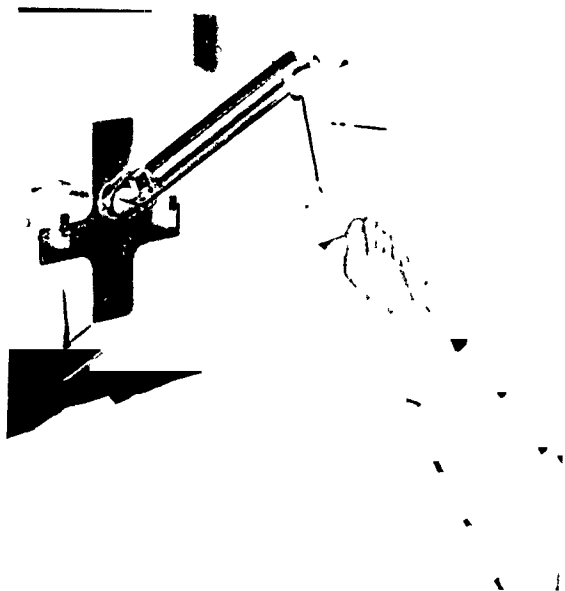


FIG. 5. Extension applied to regular bed at home.

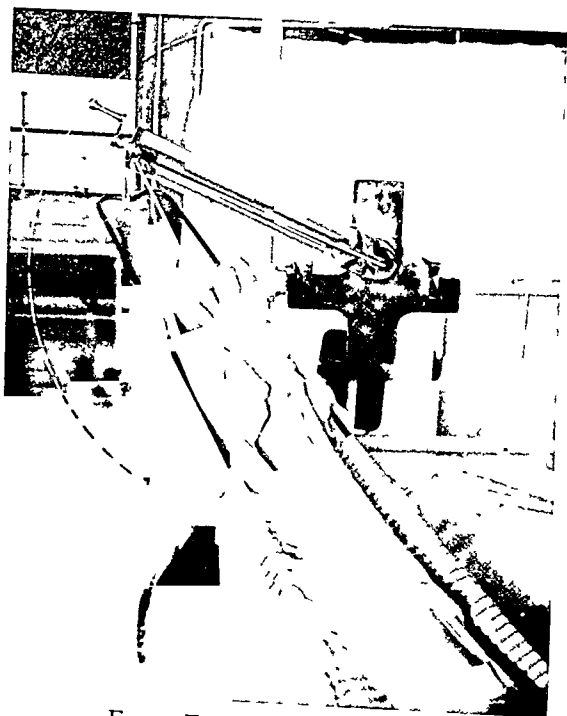


FIG. 4. Front view of extension.

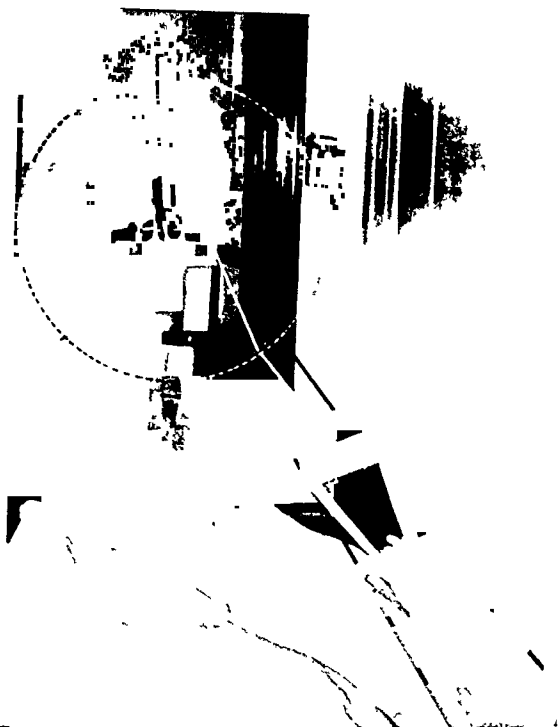


FIG. 6. How extension may be applied to fractured upper extremity.

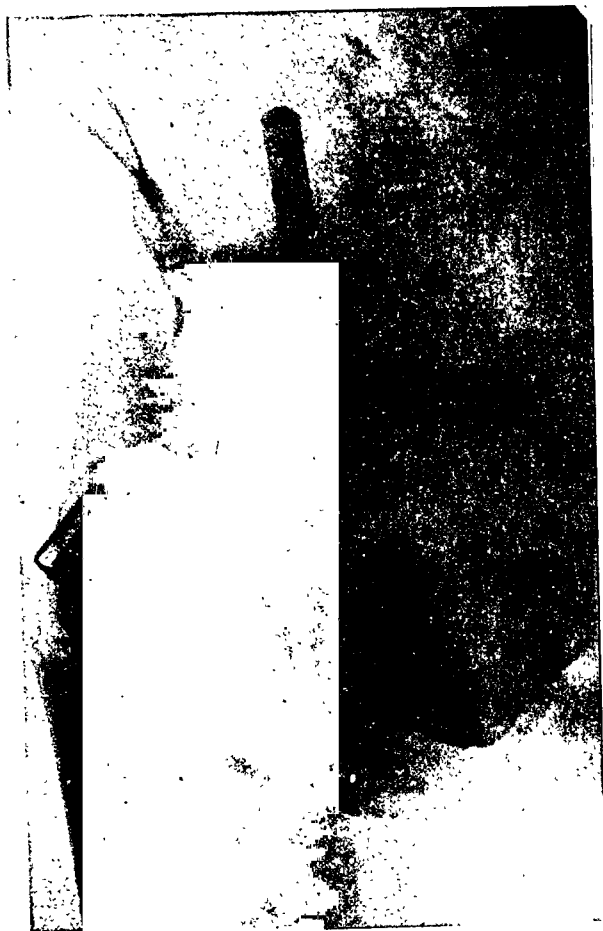


FIG. 7. Comminuted intertrochanteric fracture of right femur in patient aged fifty-five.

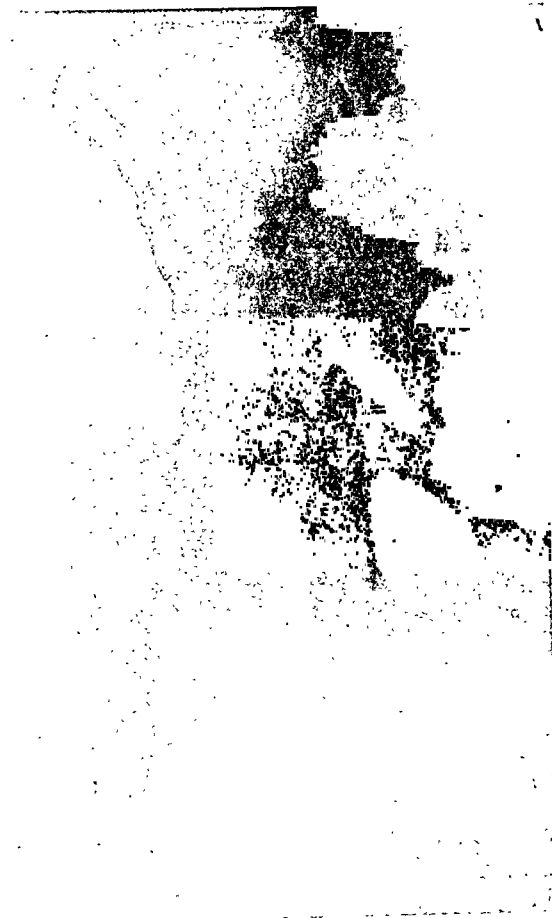


FIG. 8. Same patient nine weeks later, able to walk unaided.



# CHRONIC INFLAMMATORY VESICAL NECK OBSTRUCTIONS

## A CLINICAL AND ANATOMICAL STUDY\*

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A PERUSAL of the literature will show that there is considerable confusion in our conception of median bar, due not only to the fact that the term median bar includes obstructive elevations of fibrous and glandular types, which of themselves are separate entities, but also due to visualization of pathology through the use of different types of diagnostic cystoscopic instruments.

Diverse types of pathology are still grouped under the original descriptive term suggested by C. J. Guthrie in his lecture on median bar, delivered before the Royal College of Surgeons in London, in 1830, nearly one hundred years ago. In 1850, Mercier, in his report, described the same condition although his name has often been erroneously associated with the elevated interureteric ridge. From this date to the beginning of the present century, no really important advances can be said to have been made in the clinical or pathological conception of this subject. Since then, the work of Zuckerkandl, Alberran, Chetwood and others, followed by Lowsley's careful embryological and anatomical studies of the prostate and its contiguous structures, the thorough work of Randall on the prostate, subcervical glands and bladder neck, and the anatomical studies of the internal sphincter and vesical neck by Young and his associates, have aided materially in clarifying our understanding of the fibrotic bar and sclerotic vesical neck obstruction.

The fibrous median bar is best described as a cicatricial obstruction caused by fibrotic elevation of the posterior vesical lip with or without coarctation and constriction of the entire circumference of the vesico-urethral orifice. The relation of fibrous median bar formation to deep seated cicatricial changes in the vesical

neck and sphincter, urethral changes as well as those taking place in the prostate and seminal vesicles, has not been clearly correlated. If an infection be superimposed upon one or more of these uncorrelated structures, we may logically assume that other structures in relation to those infected will likewise become involved. Variation in anatomical structure has a direct influence on the pathogenesis. These are important points to bear in mind, not only on the diagnosis and treatment, but on the morbidity of this condition.

Because of the correlation of objective instrumental and operative observations with microscopic studies of the excised surgical specimens and routine necropsy specimens, our understanding of the gross and microscopic pictures is clear and definite. However, the problem of pathogenesis and etiology is still a moot question. The pathogenesis of a condition such as contracture must be obscure as long as the different stages in the production of terminal pathology cannot be demonstrated. The initial lesion cannot be known and appreciated without a definite conception of the pathogenesis and therefore the etiology is difficult to deduce.

In an effort to arrive at a better understanding of the underlying morbid processes of this condition, we have carried on, for the past year, a study of its pathogenesis and etiology. In this work, microscopic studies were made of 10 surgical punch specimens removed from clinically and cystoscopically proven cases of median bar or vesical neck contractures, with the McCarthy visualized punch. Parallel with this, gross and microscopic observations were made of the bladder, vesical neck and posterior urethra, and adnexa of 50 fresh cadavers selected from several hundred necropsies, while at the same time

\* Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, December 18, 1929.

cystoscopic observations were made of clinical patients presenting early and late symptoms and physical signs of vesical neck obstruction. On fresh necropsy material, visual and palpatory evidence of elevations, nodules, and contractures of the vesical neck was classified according to Randall's types of contracture or fibrous bar. From specimens showing this type of deformity transverse and sagittal serial sections were made of the posterior urethra, vesical neck and trigone, including the contiguous prostate and seminal vesicles. This enabled us to perceive the underlying pathology in the posterior urethra, prostate and seminal vesicles in necropsy material which was compared with the microscopic picture of surgical specimens removed by means of the punch in proven clinical cases. Where cases of acute, subacute and chronic infection of upper and lower urinary tracts were encountered, similar serial sections of the posterior urethra, vesical neck and trigone were made. By noting the changes in the vesical neck structures in all stages of inflammation of the posterior urethra, prostate and seminal vesicles, accurate deduction could be made of the underlying etiology and pathogenesis of bladder neck fibrosis.

In addition to the well developed prostatic glands, which empty on the floor of the posterior urethra, a homologous group of superficial glands exist in the posterior urethra, vesical neck, and trigone (Fig. 1). In many cases, they are rudimentary or absent. In other instances, they extend for varying distances into the mucosa and submucosa, and occasionally the muscularis. In the posterior urethra these glands predominate on the sides and roof. On the vesical neck and trigone, they are almost always limited to the central portion of the posterior vesical lip. Although they are given a variety of names, we shall call them submucosal glands of the posterior urethra, vesical neck and trigone. We shall later demonstrate the importance of these structures in the development of submucosal fibrosis.

Pseudo-adenomatous hypertrophy of the submucosal glands of the vesical neck or of the glands of the posterior prostatic

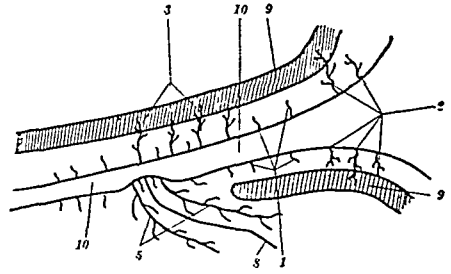


FIG. 1. Schematic representation of glandular structures of posterior urethra, vesical neck and trigone. (From Jacoby.) 1, Short mucosal glands of posterior urethra and vesical neck. 2 and 3, Submucosal glands of posterior urethra, vesical neck and trigone, reaching superficial layer of muscularis. 5, Prostatic glands arising in the premontane and postmontane urethra. 8, Ejaculatory duct. 9, Muscle of posterior urethra, vesical neck and trigone. 10, Urethral lumen.

commissure, may cause elevation of the posterior lip of the vesical neck. However, they are usually excluded when fibrosis of the vesical neck is considered, except in those rare instances where a combination of both factors exists. In the accepted conception of the pathology of vesical neck cicatrizations, inflammation is believed to account for all those cases classified as acquired. Fibrosis of the retrogressive type associated with seniel changes and arteriosclerosis, is not considered as important. Primary congenital muscle hypertrophy of the sphincter with secondary fibrosis due to congestion and infection accounts for some of the cases reported.

The excised surgical specimens in our series on the basis of the history, clinical and microscopic findings, conformed with the accepted views. One specimen, clinically and microscopically, suggested congenital hypertrophy of the sphincter with superimposed superficial, submucosal, active, chronic inflammation (Fig. 2). All the other specimens showed microscopic changes evidently due to acquired inflammatory causes, and clinically consisted of (1) cases of typical findings of contracture or bar; (2) cases of atonic bladder without a neurogenous cause; (3) one case of atonic

bladder in which a destructive spondylitis, aroused suspicion of a neurogenous element. The microscopic picture of this

urethral inflammation, as well as typical vesical neck contractures and bars, it was possible to find changes in the superficial



FIG. 2. Low-power photomicrograph of punch specimen classified as congenital hypertrophy of sphincter with active chronic inflammation in submucosa. Large vessels in submucosa indicate long-standing congestion

group of cases left no doubt as to the inflammatory factor (Fig. 3). In addition to fibrosis in the submucosa and disorganization of the muscularis by scar tissue, accumulation of round cells was found in the submucosa and muscularis, frequently perivascular and periaccinar. Glands seemed to play an important rôle in the inflammatory process in some cases, because of the depth of their penetration into the muscularis and their evident cystic dilatation and intra-acinar and periaccinar cellular exudation. All stages of inflammation were noted, from an active and recent process, to a quiescent stage of scar in which glandular elements and muscle tissue were similarly embarrassed by the fibrous overgrowth.

Based upon clinical and operative studies of cases of median bar and sclerosis of the vesical neck, and very infrequent and inadequate post-mortem examinations, the associated pathology in the contiguous centripetal structures must be a matter of conjecture. In the course of routine microscopic serial studies of the vesical neck and contiguous structures in necropsy specimens showing all stages of posterior

structures which corresponded to the microscopic findings in the excised surgical specimens. Where this occurred, the contiguous structures of the posterior urethra, prostate and seminal vesicles were subjected to careful study. By noting the effect of acute and subacute inflammation of the posterior urethra and adnexa upon the vesical neck, the preceding stages in the development of contracture of the vesical neck could be followed. In addition, the deep seated changes in the prostate and seminal vesicles could be studied in those necropsy specimens which were manifestly the last stages of fibrosis.

By a study of our material a definite conception of the pathogenesis was formed. Acute inflammation, caused by infection or mechanical irritation, results in vesical neck changes which may be regarded as an acute inflammatory bar, because of the edematous appearance of the vesical neck and elevation of the floor. This is found associated with acute posterior urethritis, prostatitis, seminal vesiculitis, and less frequently with descending urinary infection. The submucosa of the posterior urethra is infiltrated with acute inflamma-

tory exudate which is also seen in the fibromuscular stroma of the prostate. The prostatic glands show hyperplasia

of the vesical neck and trigone showed hyperplasia, cystic dilatation, periacinar and intra-acinar exudation with



FIG. 3. Low-power photomicrograph of punch specimen, typical of acquired inflammatory type. Marked fibrosis and round cell infiltration of submucosa. Muscularis shows marked perifascicular and intrafascicular fibrous and round cell invasion especially of superficial layers; chronically inflamed, cystic glands seen extending rather deeply into muscularis.

with marked intra-acinar and periacinar exudation. The mucosal and submucosal glands of the posterior urethra, vesical neck and trigone are swollen, hyperplastic and filled with acute inflammatory cellular exudate, with corresponding acute exudation and infiltration in the superficial supporting tissues (Fig. 4).

Due to continued infection, congestion or irritation of these structures, a stage of subacute or active chronic inflammation ensues. In this class of specimens, changes were noted which corresponded to some of the excised surgical tissues. In addition to typical chronic prostatitis and seminal vesiculitis, the superficial glandular struc-

round and plasma cells. Frequently a rather thick layer of granulation tissue in different stages of organization was noted in the submucosa, and in the vesical neck and trigonal regions the superficial muscle layers showed similar changes. This highly vascular fibrous reaction is unquestionably the stage preceding that of actual cicatrization of the submucosa and muscularis of the sphincter and trigone (Fig. 5).

In the final stage, corresponding to that of the excised surgical specimens, a gradual transition is seen from active chronic inflammation of the superficial glands and their supporting tissues, to the picture of fibrosis with definite evidence of chronic

inflammation which has become quiescent. In many cases, a moderate number of cystic or hyperplastic submucosal glands



FIG. 4. Transverse section of low magnification through entire prostate and vesical neck of case of prostatic abscess. Higher magnification revealed concomitant acute inflammatory exudation in and around superficial submucosal glands.

may be found in the fibrous tissue replacing the sphincter muscle. In some cases, compressed glands were noted, and in others no glands were seen. In none of the cases were evidences of inflammation absent, and from the studies of the preceding stages, it can be said that the superficial gland structures of the vesical neck play an important rôle in determining the degree and depth of the inflammatory reaction in the submucosa and muscularis, even though this may not be evident in the late stages.

In some of these specimens of frank vesical fibrosis the prostate showed a corresponding advanced sclerosis with increase in the interacinar fibrous tissue and compression of the glandular elements. In others, only mild quiescent chronic inflammation was noted in the prostate and seminal vesicles (Fig. 6).

In most of the specimens illustrating the final stage of sclerosis, there was a

definite localization of the fibrosis to the region of the posterior vesical lip. In others, the process also involved the sides and roof, but rarely to the extent that was noted on the posterior vesical lip. From our studies, it would appear that the cause for this localization is definitely due to anatomical structure, the submucosal glands of the vesical neck and trigone predominating on the posterior aspect of the vesico-urethral orifice. Productive changes in the stroma of chronically inflamed submucosal glands and subsequent cicatrization explains the fibrotic transverse elevation of the floor of the sphincter which causes obstruction (Fig. 7). The conception of this entity as a stricture of the vesical neck due to a deep seated sclerosis of the surrounding prostate is not satisfactory, since it cannot explain the transverse fibrotic elevation limited to the floor of the neck, and also fails to account for the splendid results which follow the removal of a relatively small piece of superficial tissue from the posterior vesical lip. When the coarctation is due to a small sclerotic prostate, minor surgical procedures are of no avail.

The diagnosis of vesical neck obstruction in the surgical cases was based on bimanual rectal palpation of the prostate and examination with the cysto-urethroscope, its forward vision giving an undistorted view of the posterior urethra, sphincter and bladder, and permitting an accurate estimation of the relative amount of elevation of bar formation and sphincteric change. In many instances it was supplemented by the use of the McCarthy panendoscope, not only to obtain the forward and lateral view, but as an added means of gauging the elasticity of the sides and roof of the internal sphincter. In every case, a complete urological examination was made which included detailed history, physical examination, and such roentgen and laboratory diagnostic measures as were necessary for a complete diagnosis.

While not always present in each of the foregoing cases, the presence of the obstruc-

tion at the floor of the vesical neck was often suspected when introducing the instrument, when it was found necessary

to the verumontanum to a more rounded crest. Shortening of the retromontane urethra with an appearance of excavation



FIG. 5. Low-power microscopic section through chronically inflamed and cystic submucosal gland of vesical neck region. Active chronic inflammation also seen in supporting stroma. This pathological picture represents intermediate stage of chronic inflammation preceding that of acquired inflammatory vesical neck fibrosis.

to elevate the tip at the internal sphincter. Cystoscopically there was dilatation of the bladder in one instance, marked trabeculation in all, with sacculations and diverticula in many. The presence of bas fond was constant, as well as depression or elevation of the trigone. Elevation of the sphincter floor varied from a thin to a dense transverse fold, sufficient to obscure the interureteric ridge when viewed from the urethral aspect of the bar. The post-montanal portion of the posterior urethra was seen arising almost vertically to the uppermost portion of the bar, while in some instances, it made a vertical ascent from a depression immediately posterior

on the urethral aspect of the sphincter was observed in several cases. The appearance of the mucosa, prostatic ducts and verumontanum showed no acute or subacute inflammatory change, but evident terminal fibrosis. Residual urine ranged in amounts from 4 to 44 oz.

Repeated cystourethroscopic examinations have impressed us with the fact that the vesical neck changes as seen through the cystourethroscope in these patients with fibrotic bar and sclerotic vesical neck might be considered as terminal pictures of many of the cases which are so frequently observed in practice, and who are being treated for chronic



posterior urethritis with associated chronic prostatitis, vesiculitis, and descending infections of the urinary tract. All types are

neck changes present difficulties in diagnosis which demand the utmost judgment and care in differentiation on the part



FIG. 6. Longitudinal section of floor of posterior urethra and vesical neck extending from verumontanum to interureteric ligament. Prostate shows marked increase in interacinar fibrous tissue with compression of glandular elements. Seminal vesicles show advanced sclerosis. A well defined group of submucosal glands seen extending into floor of sphincter which also shows marked fibrous invasion.



FIG. 7. Transverse section through vesical neck and adjoining prostate. Sphincter muscle shows extensive fibrosis with few compressed submucosal glands. Prostate shows definite but quiescent chronic inflammatory changes.

seen cystoscopically in these prefibrotic tissue changes: the acute, subacute and early chronic stages. The sphincter floor does not show a dense transverse elevation of the posterior vesical lip but a ridge of distinctly inflammatory or hyperplastic tissue. Its surface is engorged and often surmounted by edema of a cystic type or a more diffuse cobble-stone appearance, while often large flattened or pedunculated polyps are observed. The postmontane area is engorged and is vertical, or its rounded surface bulges toward the objective lense of the instrument; dilated prostatic ducts are often seen; the verumontanum is enlarged, shows surface edema, with ejaculatory duct openings evident at times. The findings indicating urinary obstruction, namely bas fond, trabeculation and hypertrophy of the trigone, are less in this prefibrotic stage, and residual urine is small in amount or absent. A moderate degree of intraurethral encroachment of one or both lateral prostatic lobes is not infrequently seen in these early types of cases; the encroachment is not marked and is seen to reduce and increase by turning the irrigating fluid on and off.

These inflammatory types of vesical

of the urologist. One can easily become a median bar enthusiast. The patient is often uncomfortable and frequently demands relief. The premature use of the punch or cutting current, in most instances, will not only be unsatisfactory, but results in a distinct increase in disturbance rather than an amelioration of symptoms. We believe the use of the punch should be reserved for those cases of quiescent fibrosis in which there is definite subjective and objective evidence of obstruction.

Has the frequency of occurrence of median bar been overestimated? We believe that while one frequently sees elevations of the posterior lip at the mortuary table and in routine cystoscopic examinations, they should not be confused with relatively infrequent, true fibrotic changes of the posterior lip for which the best treatment is removal by visualized punch or destruction by the cutting current, wherein the inflammatory process at the bladder neck, prostate and seminal vesicles has become quiescent.

We wish to express our appreciation to Dr. Charles Norris, Chief Medical Examiner of New York City, who permitted the use of necropsy material, without which this presentation would not have

been possible, and to Dr. Joseph McCarthy for the use of microscopic sections of some of his specimens removed by him with his visualized punch from median bars and also to Miss Alice E. Slavkin, technician, through whose untiring efforts and skill, thousands of excellent sections were obtained for this study. Our pathological work has been constantly supervised by Dr. Nicholas Alter and Dr. Lawrence Sophian, Pathologists at the New York Post-Graduate Hospital.

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## DISCUSSION

DR. NICHOLAS M. ALTER: The pathologist is often confronted with great difficulties when trying to reconstruct the various stages of the pathological process. The findings in the autopsy room and in the operating room often show terminal or advanced stages of pathological lesions. This applies particularly well to the obstructive lesions of the vesical neck where probably the earliest stages of the process cause great functional disturbance without essentially interfering with the vitality of the patient.

Specimens removed at various stages of a pathological process lead to considerable confusion in the literature in regard to classification. Drs. Hyams and Kramer have undertaken an important and difficult task, trying to clear this confusion. In the various types of obstructions they see various stages of the same process. Drs. Hyams and Kramer were relatively conservative and modest in their conclusions considering the vast amount of work and material. I had opportunity to watch this work in my department. Drs. Kramer and Hyams have been studying about 2000 slides for a period of a year.

DR. LAWRENCE SOPHIAN: I have had the pleasure of going over the material that Dr. Hyams and Dr. Kramer selected. The two phases of the work which especially deserve to be brought up are: first, the soundness of applying general pathological concepts to special regions, such as the posterior urethra; the processes can be traced through acute, subacute, and chronic stages in the vesical neck. Second, the presence in that particular location of the small submucosal glands, which are not well understood, makes a problem in that the condition is likely to persist because such glands enable the bacteria to persist and reach a state of symbiosis. These glands are related embryologically to the prostate itself and have the same embryological derivation. They do not reach further than the superficial layers, but in some sections they could be traced further in; in others, they represented small pits. We hope that by having a larger amount of material the rôle which the superficial glands play can be worked out better at some future time.

# ACUTE HEMORRHAGE FROM CORPUS LUTEUM AND GRAAFIAN FOLLICLE\*

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NOVACK, in 1917, reviewed the literature concerning acute hemorrhage from corpus luteum and Graafian follicle and reported 39 cases of copious hemorrhage into the peritoneal cavity, due to rupture of either a Graafian follicle or corpus luteum, and reported 1 case of his own, bringing the total to 40 cases up to and including 1917. The literature apparently, has not been brought up to date since that time, although case reports on this very interesting entity have appeared from time to time. A recent patient, operated upon by the writer, prompted a desire to become more acquainted with this lesion and suggested that a review of the literature to date would be interesting and at the same time valuable and instructive.

Since 1917 there have appeared 36 additional cases<sup>1</sup> in the available literature, this case making 37 additional cases, since Novack's review or a total of 77 cases appearing in an exhaustive search. I am satisfied that many other cases have occurred that have either not been reported or have not been recognized as such. For instance, no reports have been found issuing from the countries of the Far East. Practically all the cases have been reported from North and South America and Western Europe.

The case report follows:

CASE 1. Mrs. H. B., twenty-five years of age, white, married, was admitted to the Atlantic City Hospital April 7th, 1929. She had always enjoyed good health and had had no

serious diseases. Until two years ago her menstruations were irregular, but her physician gave her a gland preparation and this was corrected. Married five years and has one child. She came to this city, with her husband, three days ago to celebrate their fifth wedding anniversary. She retired the evening before in perfect health and this morning, while in the act of coition, before voiding, she felt a severe pain over her symphysis and had to interrupt intercourse. This severe pain soon abated, but a continuous pain was present and she felt nauseated. I was called to see her about four hours later. Her temperature was 99°f., pulse 80, good color, entire abdomen moderately tender, but not rigid, the peritoneal rebound was very painful. Vaginal examination did not reveal any injury to the vaginal tract nor was there any softening of or bleeding from the cervix. A mass about the size of an English walnut was felt in the right iliac fossa. This mass was not excessively tender and was considered to be an ovarian cyst. The uterus had good mobility, but motion of it caused pain over the symphysis region. Menstruation was due in about three days and the last preceding period was apparently normal in all respects.

These findings were not definite enough to allow of a differentiation between ruptured ectopic pregnancy, twisted ovarian pedicle, intraperitoneal rupture of the urinary bladder, or a beginning pelvic peritonitis.

An enema gave no relief from pain and a catheter specimen of urine contained no blood. I saw her again about four hours later and the diagnosis of severe internal hemorrhage was evident at a glance. She was extremely pale, restless, asking for water, had sinking spells, pulse imperceptible at times and complained of pain about both shoulders and up the left side of her neck. A vaginal examination did not reveal any fullness or bogginess in the cul-de-sac and the abdominal examination was the same as before except that the right quadrant had become more tender. A diagnosis of ruptured ectopic pregnancy was made.

<sup>1</sup> Cases reported by Peuch, Corlette, Roggla, Burge, Cohn, Pobedinsky, Hadden, Wilson (2 cases), Duhail, Pen, Haggstrom, Rojas, Taylor, DePage, Gross, Speese, Orth, Moore (2 cases), Greenhill, Levi (3 cases), Wilson, Hammond & Stephenson, Hayden, Feiner (2 cases), Penny, Beall, Trousseau, Valliset, Scanzoni, Schumann, Ravdin.

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She was sent immediately to the operating-room and 750 c.c. normal saline was given intravenously before the pulse became perceptible and then nitrous oxide-oxygen anesthesia was given. The field of operation having been prepared and draped while the saline was being given, an infraumbilical midline incision was rapidly made and the mass in the right iliac fossa was delivered through a pool of bright red blood which was pouring out through the incision. This mass proved to be the right ovary showing a hematoma about the size of a pecan on its posterior surface and on the surface of the hematoma there was a laceration about  $\frac{3}{4}$  in. long which was not bleeding because of traction on its suspensory ligament. The entire peritoneal cavity was apparently filled with red blood and there were a few very small blood clots. I estimate that there were between two and three pints of blood. The ovary containing the hematoma was removed and the adnexa on the left side examined and found normal. The appendix was found to be non-inflamed and was not removed. The incision was closed in layers without drainage and without attempting to remove the blood. A blood transfusion was considered, but the patient improved so rapidly that it was not necessary. She began to menstruate three days later. Her convalescence was uneventful and she was discharged two weeks later.

This case, and those included in this report, represent those serious intraperitoneal hemorrhages, which are in contrast to the rather common hemorrhagic cysts of the ovary, the latter including (1) ruptured Graafian follicles with slight bleeding, but definite hematoma, (2) hematomas of corpus luteum, (3) endometrial cysts, (4) hemorrhages into follicle cysts (5) and other types of ovarian cysts with hemorrhage into the cyst. In other words, this communication makes no attempt to include a study or classification of hemorrhagic accumulations within the ovary or even those showing moderate intrapelvic hemorrhage, but is devoted entirely to those cases causing a serious abdominal emergency and presenting the syndrome of acute internal hemorrhage.

I have been able to collect rather complete data on 25 such cases and have

tabulated the outstanding points. This analysis has been very interesting.

TABLE I

Age	No. Cases
14-20	8
21-25	9
26-30	2
31-35	4
36-40	2

TABLE II

Relation to Menstruation	No. Cases
One week before	10
One week after	4
During	1
Two weeks after	3

TABLE III

	No. Cases
Graafian follicle .	8
Corpus luteum .	18

TABLE IV

Ovary Involved	No. Cases
Right. . .	14
Left . . .	10
Both. . .	2

TABLE V

Preoperative Diagnosis	No. Cases
Appendicitis	13
Ruptured ectopic	10
Not stated.	3

Reference to Table I shows that of 25 cases, in which the age was given, the majority have occurred before or during the

thirtieth year of life; 19 cases occurring before the thirtieth year while only 6 cases occurred after the thirtieth year. No case occurred before the beginning of menstrual life or after the menopause. The cases are about equally divided between married and single women.

Table II compiled from 18 cases in which the time relation to menstruation was stated, shows 15 cases occurring within the period of one week before, during, and one week after menstruation. Only 3 cases occurred in the remainder of the interval between menstruation.

Table III shows that 8 of the cases were due to a rupture of a Graafian follicle, while 18 were due to rupture of a corpus luteum. Therefore ruptured corpus luteum occurs about twice as often.

Table IV shows that the right ovary was involved in 14 instances, the left in 10 instances, the condition being bilateral in 2 cases.

Table V shows that the preoperative diagnosis was acute appendicitis in 13 instances and ruptured ectopic pregnancy in 10 instances.

Comparison of Tables IV and V suggests that the diagnosis of appendicitis is roughly equal in number to the cases showing hemorrhage from the right ovary, while the number of cases diagnosed as ruptured ectopic pregnancy corresponds to the number of ruptures of the left ovary. It therefore appears that when the right ovary ruptures and causes hemorrhage the condition is diagnosed as acute appendicitis, and when the left ovary is involved the diagnosis is usually ruptured ectopic.

So far as I have been able to determine the correct diagnosis has never been made before operation. Schumann reports 1 case in which he diagnosed intraperitoneal hemorrhage due to a ruptured follicle or corpus luteum and treated the case expectantly with recovery. The diagnosis in this case was not proved by operation and therefore the diagnosis must remain open to question.

Orth reports a very interesting case:

A woman twenty-six years of age was operated upon for acute appendicitis and a suppurative appendix removed. During the fourth night after operation the patient had uterine bleeding which was believed to be menstruation. On the following day, however, there was a striking and rapidly increasing anemia. A second operation was performed and 1.5 liters of blood was found in the peritoneal cavity. The source was a ruptured right Graafian follicle. After this operation the patient improved, but twenty-four hours later another hemorrhage occurred. A third operation revealed the source of bleeding to be a ruptured left Graafian follicle.

To discuss the etiology of profuse hemorrhage from a Graafian follicle or corpus luteum necessitates a review of the physiology of ovulation and the subsequent changes in the follicle after the ovum has been extruded.

#### ESSENTIAL PHYSIOLOGY

At birth the ovaries contain about 30,000 primitive or primordial follicles. Activity resulting in ripening of these follicles does not eventuate in the extrusion of the ovum until menstrual life begins. However, activity of growth probably begins even before birth of the child and this activity results in the formation of atretic follicles. After menstruation begins one Graafian follicle ripens and ruptures each month and many more never become ripe and go on to the formation of atretic follicles without extruding their contained ova. When, however, the Graafian follicle becomes ripe and the ovum is thrown out, rupture occurs through the stigma, hemorrhage of a physiological nature takes place and the cavity becomes filled with a hematoma. The formation of the corpus luteum then begins with repair of the laceration and organization of the blood-clot. It is thought that the cells lining the original Graafian follicle, the granulosa cells, enlarge and possibly multiply and that lutein is deposited in these cells, probably from the organizing blood-clot, giving the characteristic yellow color to the corpus luteum. The blood vessels,

which enter through the hilus of the ovary, give branches which supply each developing ovum and during the formation

hematoma forms in the corpus luteum cavity and if hemorrhage persists long enough the pressure in that cavity will



FIG. 1. Low power (ca. 75) showing edge of follicle into which hemorrhage occurred.

of the corpus luteum, in the lutein layer, are found many thin-walled vascular bud-like projections. The corpus luteum has a very short life, about three or four weeks, and this is followed by the corpus albicans which finally disappears, leaving a permanent scar on the surface of the ovary.

#### THEORY AS TO CAUSE OF HEMORRHAGE FROM CORPUS LUTEUM

We have seen above how thin-walled vascular bud-like projections are present in the lutein layer during the formation of the corpus luteum. It is easy to imagine injury or a solution of continuity of these fragile vessels brought on by a sudden hyperemia of the pelvic organs, as by sexual excitement, or by a sudden increase in the intravascular pressure due to sexual excitement or increased intra-abdominal pressure. After injury to these vessels a

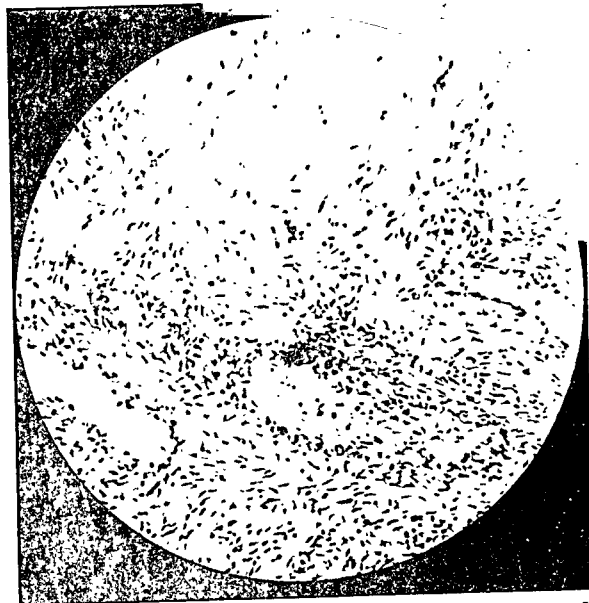


FIG. 2. High power (ca. 250) showing blood vessels without indication of pathological changes.

become so great as to burst the wall at its weakest point. It has been proved that a large proportion (60 to 80 per cent) of all ovaries removed at operation show hematoma formation in some part of their structure, showing the vulnerability of the smaller ovarian vessels. This bursting of the walls of the corpus luteum might eventuate in a copious hemorrhage or in a trivial one. This seems to me the theory most likely. Whether there is a pathological condition of the ovarian (or more strictly, thecal) vessels, as shown by Schumann to be present in his case, remains unsettled. Reference to the pathological study in my case is included in this paper. The pathological changes in the vessels in Schumann's case is a very interesting observation, but whether there was any relation between such pathology and the hemorrhage is debatable. The question of cause and effect is not thereby demonstrated for there is no reason why the hemorrhage could not have been a coincident condition. I do not believe that changes in the vessels alone would satis-

factorily explain the occurrence of hemorrhage.

#### THEORY AS TO CAUSE OF HEMORRHAGE FROM GRAAFIAN FOLLICLE

Returning to the normal physiology of the ripening Graafian follicle, we note that hemorrhage occurs into the cavity after the ovum has been expelled. This hemorrhage occurs from the thecal vessels. The additional physiologic hemorrhage from the lacreation through the stigma is no doubt negligible because the point of rupture has become so thinned out by the pressure of the developing follicle. A pressure ischemia of an obliterative nature would seem most logical in the production of the stigma. Presuming that in the ovary a Graafian follicle is almost, but not entirely ripe, when a sudden hyperemia of the pelvic organs occurs and causes an increased intravascular pressure in the ovarian blood vessels, premature separation of the ovum within the follicle might occur. This premature separation would produce hemorrhage into the follicle and if this hemorrhage was continued sufficiently long a bursting of the follicle at its weakest point would naturally occur. Intraperitoneal hemorrhage would then take place from both the thecal vessels and from the laceration in the ovary. This hemorrhage might be copious or trivial. I believe that in all the cases presenting serious hemorrhage such a process occurs in Graafian follicles that are not quite ready to rupture. In other words a premature separation of the ovum, with hemorrhage, and premature rupture of the follicle are the mechanisms producing the condition under discussion.

It is very significant that in the 25 cases, used as a basis of study for this paper, that increased intra-abdominal pressure was specifically mentioned in 9 cases. Eight of these patients stated that intra-abdominal pressure was increased either by vomiting or by straining at stools. In view of the frequent diagnosis of appendicitis in these cases and realizing

that the majority of appendicitis cases vomit one or more times, I am satisfied that the incidence of increased intra-abdominal pressure would be greatly increased if definite records of this point had been made in all cases. It is interesting, however, that it was definitely stated in approximately one-third of the cases studied.

Dr. Robert Kilduffe, Director of Laboratories at the Atlantic City Hospital, has furnished the following report on my case after a very thorough microscopic study of the excised ovary.

Mrs. H. B. The specimen consists of an ovary which has been opened in its long axis. The tissue is pale in color and appears fibrotic. At one margin is a corpus luteum. In another area there are several punctate hemorrhages which appear to have arisen in the walls of a Graafian follicle.

*Microscopy:* (formalin fixation; paraffin sections.)

Particular attention attaches to the area in which hemorrhage has occurred. There is a partially organized blood-clot, the margin of which is enclosed by a layer suggesting in appearance the theca interna folliculi. The blood vessels throughout the sections show no evidence of pathological changes, which also are absent in the ovarian structure in general. There is nothing in the sections to indicate the cause of hemorrhage.

It is now interesting to note the rather positive value of this pathological report, in that there was no demonstrable disease of the ovarian vessels or specialized cells. It is thus demonstrated that in this case we began with an apparently normal ovary going through the physiological cycle of ovulation and maturation, that something suddenly went wrong, that a hematoma formed within the follicle apparently, and that later the follicle ruptured. This must evidently be called an accident. Increased intra-abdominal pressure and pelvic engorgement, both brought on by cohabitation, apparently was the exciting factor.

Novack writes:

The cause of hemorrhages emanating from the ovary (what might be called perforative ovarian hemorrhage) is in a large measure similar to those of ovarian hemorrhage of the non-perforative type, in which hemorrhage is confined in the ovary, giving rise to hematomas of various sizes. The principal predisposing factors, as might be expected, are conditions which bring about hyperemia of the ovary, with engorgement of its vessels. This hyperemia may be of either the active or the passive type. Practically always, as my study has shown, the bleeding comes from the thecal vessels of structures derived from Graafian follicles, but even more often from the walls of corpora lutea or corpus luteum cysts. The occurrence of free bleeding from the ovary into the abdominal cavity would thus depend largely upon the follicular structure involved. If it lies near the surface it can be easily understood that the thin wall may be broken through by the blood which escapes from the engorged vessels and free abdominal hemorrhage thereby results.

#### DIAGNOSIS

What is the possibility of making a correct diagnosis before operation? This study has found 77 cases reported with a diagnostic error of exactly 100 per cent, no case having been diagnosed correctly previous to operation.

The greater number of mistakes have been made in diagnosing the condition as acute appendicitis, because of the pain in the right lower quadrant, vomiting, fever and leucocytosis. It therefore appears that the physical examination must be the all important factor. The chief differences in favor of hemorrhage from the ovary would be:

1. Pallor of skin and mucous membranes.
2. More shock.
3. Fainting or sinking spells.
4. Less amount of rigidity of rectus which, in fact may be absent.
5. Area of exquisite tenderness is rather definite in appendicitis, while with ovarian hemorrhage the tenderness is rather diffuse over the lower quadrants.

The differentiation from ruptured ecto-

pic pregnancy is more difficult. They both have in common:

1. Cramp-like pains over one or the other lower quadrant.
2. Fainting or sinking spells.
3. Evidence of internal bleeding.
4. Fever and pulse elevation.
5. Leucocytosis.

Ruptured ectopic pregnancy usually gives a history of one or more abnormal menstrual periods, there is usually some vaginal bleeding, softening of the uterus just proximal to the internal os may be present, and the breasts may show the changes of early pregnancy. If there is bleeding, not menstrual in type, from the uterus the case is probably not one of ovarian hemorrhage. This vaginal bleeding was present in only 1 of the 25 cases studied.

However, it is much easier to make the diagnosis on paper than it is in practice and without practical experience to keep this possibility in mind past records suggest that the condition will be confused with the two commoner ones, appendicitis and ectopic pregnancy. The diagnosis should not be missed by those who have encountered the condition.

#### TREATMENT

The treatment is immediate operation. A midline infraumbilical incision is the proper approach. Resection of the Graafian follicle with repair of the ovary is the operation of choice and should be done when the patient's condition permits. Removal of the entire ovary can usually be accomplished more rapidly and should be done without hesitancy if the patient is in poor condition. No drain should be used and neither should the blood be removed from the peritoneal cavity, although it is probably wise to remove large blood-clots. Examine the appendix but do not remove it unless the patient is in very good shape. Examine the opposite ovary as bilateral hemorrhage may be present.



## PROGNOSIS

Of 77 cases appearing in the literature there have been 6 deaths reported.<sup>1</sup> This number is probably too small, but if correct, means a mortality of nearly 8 per cent. Two of the patients died within a few hours without operation.

## SUMMARY

1. A review of the literature with report

of an additional case is presented, making a total of 77 cases.

2. A critical study of 25 cases, in which rather complete data was available, has been attempted.

3. Acute hemorrhage apparently may occur from a normal ovary and present a serious abdominal emergency.

4. A theory as to etiology is discussed.

5. Diagnosis, prognosis and treatment are outlined.

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# RENAL TUBERCULOSIS

CHANGING CONCEPTIONS IN THE DECADE 1920-1930\*

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IN reviewing the literature on the subject that has appeared during the last decade one is impressed by the change in long-cherished ideas. The teaching that renal tuberculosis is never primary but always secondary has so assumed the dignity of age that it is seldom questioned, and when tuberculosis is found elsewhere in the body its rôle as a primary focus is at once cast and the renal involvement is considered secondary. The idea has rarely been considered that tuberculosis of the bones and joints, or other extrapulmonary tuberculosis, probably originates from the same focus that affects the kidney and that the renal involvement is not secondary to the tuberculosis of the spine or hip but coincident with it.

It seems probable, after careful consideration, that the original focus is usually in the respiratory system. A lymph node in the hilum of the lung becomes involved, the bacilli of tuberculosis readily pass to the lymphatic duct and thence to the blood stream; their final situation becomes a question of the relationship of local resistance to the amount and virulence of the infection present. If joint, bone and kidney are all involved, the involvement of the various structures probably occurs approximately at the same time.

If this hypothesis is correct, then involvement of both kidneys must be more common than our clinical experience would seem to indicate. This idea was formulated and presented, with clinical evidence, by Chute in 1920. He reviewed 3 cases which occurred in his practice and he considered that there were indications in occasional cases that tuberculous processes of the kidney healed. He pointed out how such a belief is necessary if one is to accept the hypothesis of the hematogenous route of the infection. He said:

I believe we must assume that tubercle bacilli are brought in approximately equal numbers to both kidneys, but little cortical tuberculous infections are common and that far from going on to the complete destruction of every kidney that is infected they are probably promptly stamped out in by far the greater majority of instances. The generous blood supply of the kidney allows it to overcome perhaps the greater number of infections while yet they are incipient.

The wisdom of this hypothesis has been emphasized yearly in the last decade by clinical or experimental work, and we believe the evidence to be so conclusive as to convince urologists that earlier teachings of this subject need modification.

In 1921, Hyman and Mann reviewed 126 cases of renal tuberculosis observed at Mt. Sinai Hospital in the previous eight years. They concluded: "The presence of tubercle bacilli alone in smears or in catheterized ureteral specimens does not justify a diagnosis of renal tuberculosis; pus or microscopic blood must be found associated." This may be interpreted, although not so intended by the authors, in the light of work then being done by Lepper, as meaning that until the tuberculous process had extended so that blood and pus were present in the urine, the diagnosis of renal tuberculosis was not justified, because such a diagnosis implied the necessity of nephrectomy. While Hyman and Mann were collecting their clinical data, Lepper was investigating the experimental production of infections of the urinary tract with coliform organisms. She found, with but a single exception, that after the intravenous injection of coliform organisms there was always evidence of renal changes before the organisms appeared in the urine.

In 1922, Dyke presented a paper in

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which he demonstrated that cocci cannot pass through a normal kidney, and he threw grave doubt on the theory that secretory bacilluria of any kind can take place. In reviewing the literature, he found that Cohnhein, in 1882, apparently without making any experimental observations, first expressed the belief that bacteria pass through the normal kidney. The first experimental work was carried on four years later by Wyssokowitsch who concluded that the appearance of bacteria in the urine is dependent on the initiation of lesions in the substance of the kidney for he could not demonstrate urinary infection for at least six hours after intravenous injection and then only when the infection was associated with the presence of blood in the urine. His observations were confirmed by Boccardi, working with *Banthrasis* in 1888, and Pernice and Scagliosi, in 1892, using *staphylococcus*, concluded that organisms do not pass through an uninjured kidney. Sherrington, in 1893, reinvestigated the problem with the utmost thoroughness, and stated, "At a time when the blood is teeming with microorganisms there may not be the slightest transit of them into the urinary fluid then secreted." These data were further confirmed by Sittman, in 1894, and by Colten, in 1895, who demonstrated injury of the kidneys which had proved permeable to the passage of organisms, and he concluded that they were excreted only when lesions were present in the kidney.

Investigators up to this time had been in agreement and had employed a technic which usually consisted of obtaining specimens of urine without the use of catheters by puncture of the bladder with small needles through seared surfaces.

Biedl and Kraus and von Klechi, in 1896, investigated the subject. They placed cannulas in the cut ends of ureters and found that the kidneys excreted the organisms almost at once. As a result of their work the theory of secretory bacilluria became well established and it was not

until the work of Dyke and Lepper, and more recently of Helmholtz, that their error in technic was demonstrated and that the more extensive and accurate work of the earlier investigators was again established. One can now readily appreciate how subject to contamination must be any urine obtained by a technic that involves cutting of the ureters when the entire circulatory system is filled with bacteria. Thus, a slight error of technic established an erroneous teaching.

In 1923, an incident took place which led to an important further study. A surgeon performed nephrectomy because bacilli of tuberculosis were found in a specimen of urine from the ureter. Since gross pathological changes could not be demonstrated in the removed organ, the surgeon attributed the pathologist's finding of the organisms to an excretory bacilluria and threw on the pathologist the responsibility for removal of the evidently normal kidney.

The pathologist was Medlar, and late in 1924 he and Sasano, after a most careful experimental investigation, published their work entitled "Experimental Renal Tuberculosis with Special Reference to Excretory Bacilluria." After intravenous injections of bacilli of tuberculosis had been given to a series of guinea pigs, their urines were injected into other pigs, after which the kidneys of the pigs with urines positive for acid-fast bacilli were examined. Medlar found that it was necessary to run serial sections in order not to overlook lesions, but he found, by this method, that every pig with a urine positive for acid-fast bacilli had renal involvement. He concluded that in the numerous cases reported in the literature in which organisms of tuberculosis have been reported to have been excreted from normal kidneys, lesions exist which only serial section will demonstrate.

In examining serial sections, Medlar found lesions that were in the process of healing and he concluded his report with the assertion: "Individual tuberculous

lesions of the kidney may heal," and further, "No evidence to support the excretion of tubercle bacilli from normal kidney has been found." He also observed that experimentally the size of the tuberculous lesion is no criterion as to the number of bacilli present and that there may be extensive renal involvement before any organisms get into the urine.

Also in 1924, Bugbee reported 2 cases representing unusual types of renal tuberculosis in which bacilli of tuberculosis could not be isolated from the urine or demonstrated by inoculation of guinea pigs. He concluded his article with the following sentence: "They lead one to believe that tuberculosis of the kidney probably exists much more frequently than is generally conceded, that a correct diagnosis of this type of case is often overlooked, and that such a low grade tuberculous renal infection is self limiting in some cases." Thus was clinical evidence presented to substantiate Medlar's experimental work. The latter presented his experiments before the American Association of Genito-Urinary Surgeons and in the discussion of the paper Hagner remarked:

Another point is the occurrence of the tubercle bacilli in the urine without tuberculosis in that kidney. Experimentally that may occur but I would like to ask any man in this audience if he has ever seen a case in a human where tubercle bacilli were present in the urine, operation done, and no tuberculosis found in the kidney. I have never seen such a case. If we find tubercle bacilli in the urine, I believe that patient has tuberculosis of the kidney.

This illustrates how rapidly the ideas of renal tuberculosis were changing even by the middle of the decade.

In June, 1925, Helmholz and his associates published the first of a series of papers entitled "The Kidney, a Filter for Bacteria." They did not find bacteria in the urine until sufficient time had elapsed to permit of renal injury and they were always able to demonstrate the injury microscopically. They used many

different bacteria, and even produced extensive lesions with one organism; they then injected a different organism to see if it would come through at once, and in one series of experiments they produced hydronephrosis before the injection. But even in the presence of gross pathologic change, the kidney held back the organisms sufficiently long for characteristic lesions to form. Helmholz remarked:

The generally accepted mode of sterilization of the blood is not by excretion but through phagocytosis by the endothelial cells and in the endothelial cells of its large capillary bed. The kidney possesses a large phagocytic field which can dispose of large numbers of bacteria. The kidney can and does rid the circulating blood of bacteria but by means corresponding to those of other organs and not by secretion of organisms.

The next year, in 1926, Medlar reported on the pathologic examination of 100,000 serial sections from the kidneys of 30 patients who had died of advanced pulmonary tuberculosis but who had not had clinical symptoms of renal involvement. In 22 of these cases, renal tuberculosis was found. In every case in which both kidneys were examined, the disease was bilateral. Since definite scars were present in 17 of the cases, he concluded that tuberculous lesions of the kidney heal.

Previously Braasch and Scholl had reviewed 22 cases of renal tuberculosis in which nephrectomy had been done and guinea pigs had been given injections of urine from the supposedly normal kidney. They were surprised to find evidence of tuberculosis in 7 cases. Beer had reported similar results and had attributed them to renal reflux.

We recently have reviewed the ultimate results in cases seen at The Mayo Clinic up to January 1, 1929, in which guinea pigs were given inoculations with urine obtained before operation from the supposedly normal kidney (Table 1). There were 175 such cases; in 23 the test was a failure, in 109 negative results were obtained in the guinea pigs and in 43 the

results were positive. Two of the 43 patients died in the hospital and 11 died subsequently. Of the 30 who remain 13 have unquestionable involvement of the remaining kidney; 3, we could not trace, and 14 are well. Urine from 2 of these when inoculated into guinea pigs, in the course of reexamination of the patients, has given negative results. Do these 14 cases represent instances of reflux of urine up the ureter of the good kidney at the time of examination, as suggested by Beer, or do they represent early involvement of the kidney that subsequently has healed? Possibly they represent a proportion of both. It surely seems somewhat dogmatic to assert that, if the patient dies subsequently, that the ureteral specimen gave a correct impression of disease of the kidney, whereas, if he lives, the interpretation must always be that there has been an error of technic. For after the splendid investigative work of Helmholtz, Lepper and Dyke one can no longer advance the conception of excretory bacilluria as an explanation.

Also in 1926, Morse and Braasch, in their article on the comparative value of inoculation of guinea pigs in the diagnosis of renal tuberculosis stated; "The clinic records do not show a single case in which the diagnosis of renal tuberculosis was made from finding a positive stain or guinea pig inoculation in which tuberculosis of the kidney was not found at operation."

In 1927, Thomas and Kinsella gave their preliminary report of clinical research in renal tuberculosis that they had carried on for a number of years at Glen Lake Sanatorium in Minnesota. Their results were strikingly similar to those which Medlar obtained. They wrote:

We cannot understand why tubercle bacilli behave differently in the kidney than in other tissues in that a renal lesion is not supposed to heal. We believe that tubercle bacilli are carried to the kidney by the blood stream and that every renal infection with tubercle bacilli must be primarily bilateral. One kidney

may not overcome the infection as well as its mate and a destructive lesion develops. We have never removed a kidney which eliminated tubercle bacilli that did not contain a lesion of tuberculosis. Renal tuberculosis may end in clinical arrest or cure.

In June, 1928, Wildbolz of Switzerland delivered in Chicago an address on renal tuberculosis. He attributed the recovery of approximately 60 per cent of his patients on whom operation had been performed to the fact that renal tuberculosis was usually unilateral, but he refused to attribute the 40 per cent of deaths to the possibility that the disease ever originated as a bilateral infection. He energetically expressed his disapproval of the radical views which were developing in America concerning the etiology and progress of the infection, and he held firmly to the long-taught theories of secretory bacilluria and inability of a tuberculous renal lesion ever to heal. The chief interest of his paper lay in his description of tuberculous nephritis; he said:

Caseation and cavity formation are lacking in the infected tissue but there is also no formation of tubercles. The renal parenchyma does not react in such cases to the invasion of the tubercle bacillus with specific tuberculous tissue changes; on the contrary the bacilli may not infrequently produce only a non-specific infiltration with a tendency to fibrosis of the kidney. Why the tubercle bacillus in rare instances causes only non-specific inflammatory changes in tissues without tubercle formation or caseation cannot be stated with certainty.

The lesions he described resembled somewhat those described by Bugbee in 1924, and Wildbolz explained some of his apparent cures of renal tuberculosis to this type of the disease.

Also in 1928, we reviewed the clinical material relative to tuberculosis of the genital tract among the patients who had come to The Mayo Clinic prior to January, 1923. The cases which had occurred in the previous five years were excluded in order that the final results might be better

determined. In a review of 300 cases we found that dysuria was usually a symptom of urinary tuberculosis and that it occurred rarely when the disease was confined to the genital tract. We also found that "the presence of the bacilli of tuberculosis in the urine indicated renal involvement." In using the word "indicated" we intended to imply the idea of "probability." For instance, when the sky is overcast, one may say "that indicates rain." Doubtless it would have been clearer if we had said "almost always indicated renal involvement," for the sentence seems generally to have been interpreted as an absolute statement. At the meeting of this Academy last year, Beer referred to our conclusion as rash and he further stated: "In males, prostatic tuberculosis may lead to a clinical picture quite similar to the cystitis of renal tuberculosis and . . . perhaps 15 per cent may have tubercle bacilli in the bladder urine."

In spite of our high regard for Beer we believe it is only rarely that tuberculosis of the genital tract can be given as the source of bacilli of tuberculosis in the urine. Accordingly we have recently reviewed again the 300 cases of genital tuberculosis seen at The Mayo Clinic prior to 1923 and have included 306 additional cases examined prior to January, 1929. This series, which includes a total of 606 patients, we believe to be sufficiently large to enable accurate conclusions to be drawn. In 73 of these patients renal tuberculosis was proved to be present although the urine was negative for bacilli of tuberculosis. Two hundred and fifty-seven patients had urine that was positive for bacilli of tuberculosis: 170 of these patients underwent nephrectomy for renal tuberculosis. This leaves 87 patients of the 257 who were not operated on. Fifty-seven of these 87 patients who were not operated on have died since. In these 57 cases the renal source of the bacilli had been demonstrated by cystoscopic examination in all but 12, in which cystoscopic demonstration was not justifiable

because the disease had advanced so far that renal calcification had resulted. Of the 30 cases which represent the difference between 87 and 57 the disease had invaded both kidneys in 20 and was unilateral in 8; this was demonstrated by cystoscopy. In the remaining 2 cases of the 30, that is, in 2 cases of 257 we were unable to demonstrate the renal origin of the bacilli of tuberculosis and we believe, as Dr. Beer has suggested, that the organisms may have been of genital origin. An incidence of less than 1 per cent surely will justify our saying that the presence of bacilli of tuberculosis in the urine almost always indicates renal involvement.

The last year of the decade we are reviewing was ushered in with an article by Harris entitled "Tuberculous Bacilluria." In scope and thoroughness of the work represented by this article, it has few equals. Its author studied 43 adults and 67 children who had surgical tuberculosis outside the urinary tract and found an incidence of 37 per cent of tuberculous bacilluria in adults and 13.8 per cent in children. In the majority of these cases, urinary symptoms were not present. We do not believe the frequency with which urinary tuberculosis occurs without symptoms is generally appreciated. In a recent review of 345 cases in which stained smears of urine contained acid-fast bacilli at The Mayo Clinic 28 patients (8 per cent) had no complaint referable to the urinary tract; from 23 of these patients, tuberculous kidneys were removed. The other 5 also had renal tuberculosis but operation was thought inadvisable.

Harris was interested to see if he could demonstrate that any of the unexpected incidence of symptomless tuberculous bacilluria was of the secretory type. At the suggestion of Klotz, he collected urine daily for ten days from 3 patients who were free of symptoms referable to the urinary tract but who had tuberculosis elsewhere. He wrote:

Each of these daily specimens produced tuberculosis when inoculated into guinea

pigs. In other words, tubercle bacilli were present in the urine every day though the patients were free from symptoms. Were their presence due to excretion from the blood stream by the kidney, an equally constant tuberculous septicemia must have been present. A tuberculous septicemia so constant and severe could hardly exist without the occurrence of miliary tuberculosis. None of the patients had at that time nor have they at present any evidence of miliary tuberculosis. Blood cultures taken during the periods when urine was collected were free from tubercle bacilli. It seems certain, therefore, that the tubercle bacilli came from foci of renal tuberculosis.

At the conclusion of Harris' paper he added: "It is reasonably certain that the presence of tubercle bacilli in the kidney urine means the presence of tuberculous lesions in the kidney." Since a goodly proportion of the patients without symptoms, but with bacilli of tuberculosis in the urine, ultimately became free of the organisms, as indicated both by examination of stained smears and by the results of inoculation of guinea pigs, it is not strange that in his conclusions he stated: "The initial renal lesions frequently heal, less frequently they steadily progress to complete destruction of the kidney and death of the patient."

In June, 1929, Thomas brought to a close the list of stimulating papers on the subject of renal tuberculosis that had appeared in the decade. His was a report of a ten years' clinical study at the Glen Lake Sanatorium in Minnesota. Among his conclusions were two statements that ten years before would have been considered rank heresy: (1) "renal tuberculosis is in the majority of cases a bilateral condition" and (2) "non-destructive lesions will heal and the patient with this type of lesion should have the advantage of sanatorium treatment to assist him in building up a resistance against tuberculosis."

We do not feel that a review such as this, of the last ten years' work, is justified unless we can add some evidence that will contribute toward the change to the

present conception of renal tuberculosis. Since many cases of extensive tuberculosis of the bones, joints and lungs, as well as many cases of tuberculosis of the urinary tract are seen at The Mayo Clinic, we hoped, by reviewing all cases in which there were bacilli of tuberculosis in the urine, to discover at least some confirmatory clinical evidence to substantiate the newer ideas relative to renal tuberculosis.

During the six years between 1923 and 1929, 5971 smears of urine were stained, of which 570 were positive for organisms of tuberculosis and represented specimens from 345 different patients. Two hundred and forty-three of these patients underwent nephrectomy for tuberculous kidney, either at the clinic or elsewhere (Table 11). The remaining 102 fell into 5 groups when studied carefully. In the first group were 17 cases in which the concentration of urea in the blood was so high as to indicate hopeless renal impairment, presumably bilateral; 13 of these patients are known to be dead. The second group of 47 patients, of whom 25 are dead, represents an earlier stage of the same condition; involvement was demonstrated as bilateral by cystoscopic examination, instead of being inferred from the demonstrated renal insufficiency. Some of these patients possibly might have been benefited by removal of the more involved kidney. At least, operation might have done no harm, for Braasch called attention to the fact that when nephrectomy had been performed, and, following this, urine from the supposedly normal kidney was found to have given a positive test on inoculation of a guinea pig, the subsequent mortality and the subsequent improvement are practically the same as in those with, so far as can be determined, strictly unilateral involvement. A third group of 20 cases comprised those patients with tuberculosis of the lungs or bones so extensive as to preclude any thought of renal surgery. Eleven of these patients are known to be dead. Of the remaining 9, 4 could not be traced, and 2 have persistence of vesical

symptoms. The urine of 1 of the other 3 patients, a man aged twenty-one years, was found to be positive for bacilli of tuberculosis. The left kidney was found to be the source of these organisms, and since all other observations gave negative results, heliotherapy was advised. The patient now reports himself to be well. The second patient was a man, aged twenty-four years with Pott's disease and pleurisy, without urinary symptoms or demonstrable genital involvement but whose urine from the left kidney was positive for bacilli of tuberculosis. Because of the multiple foci of tuberculosis, nephrectomy was not done and heliotherapy was advised. On inquiry three years later, he reported that he was doing manual labor in a section gang and feeling fine. The third patient, a child with Pott's disease, still is under treatment in a sanatorium. Possibly this was a case of excretory bacilluria, but after Harris' excellent investigation of this type of case, we are inclined to doubt it. The fourth group comprises 6 cases in which nephrectomy was advised but refused.

The fifth group comprises the 12 remaining cases out of the original 345 in which the source of the tuberculous bacilluria is in doubt. In 1 of these, calcification of the kidney, several years later, indicated the origin. In 2 others there was extensive genital involvement, and cystoscopic examination was not made. Since the pyuria was extreme, it is doubtful if the bacilluria was entirely due to genital contamination.

One case had all the features of secretory bacilluria. Following the removal of a tuberculous tonsil, acid-fast organisms were found in a single specimen of urine. Subsequent specimens were all negative for bacilli of tuberculosis. Since 5 of the remaining 8 patients were women, we believe that the smegma bacillus was mistaken for the bacillus of tuberculosis. If, however, we accept the 7 cases in males, in this group, as examples of tuberculous bacilluria of genital origin, the proportion is only 2 per cent. However, in 4 of the 7 there was no palpable evidence of genital disease. Since tests with guinea pigs gave negative results in the 4 cases in which no evidence of genital disease was found, we believe the organisms found in the stained smear were probably smegma bacilli. As previously stated, 1 of the remaining 3 male patients was later found to have a calcified kidney, leaving but 2 patients who did not present evidence of a renal origin of the bacilli.

#### CONCLUSIONS

1. Initial tuberculous lesions in the kidney frequently heal.
2. It is not possible for a normal kidney to filter bacilli of tuberculosis out of the blood stream into the urine.
3. The presence of bacilli of tuberculosis in the urine almost always indicates renal involvement.
4. Dysuria is a symptom of urinary tuberculosis and does not occur when the disease is confined to the genital tract.

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# EVALUATION OF DENTAL ROENTGENOGRAPHIC SHADOWS\*

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THERE are two chief sources of possible error, or rather, differences in interpretation, in any roentgenogram. The first is the film, which of course is a variable factor because of the technic of the operator, and the second is the personal one. With the improved methods of portrayal of anatomical parts and more particularly the dental areas, and the modern perfected machines for roentgenography, a more standardized way of portrayal has been developed. Therefore, the exposure and development of the films, which is the first factor, will not be stressed but rather the second, the value to be placed on the shadows developed. Their easy identification as either expression of normal entities or of some pathological significance will be given greater consideration. It is presupposed that the technical procedure of exposing films of the dental areas will have been done in the most approved fashion. This must be done with a knowledge of the anatomy of the jaws, so that the bony landmarks will be portrayed in a manner that they may be recognized and prove of diagnostic assistance where necessary, and with sufficient bony definition to portray the intimate character of the surrounding alveolar process. It is in these areas that most of the changes of diagnostic value are to be found.

Assuming that the character of the film is such as to portray the teeth and their surrounding alveolar process in good contrast, we may then proceed to describe a rule from which we may formulate the value of the various shadows and their relation to the normal or abnormal or even pathological arrangement of parts.

It will perhaps not be amiss to call

attention to the fact that the shadows or silhouettes seen on the film are not those commonly considered, but rather silhouettes within shadows. The appearance of the silhouetted parts is due entirely to the peculiarity of the roentgen-ray force: the ability of penetrating areas in proportion with resistance encountered. We record this invisible penetration on the sensitized film. The force of this penetration is registered on the film in inverse ratio to the resistance encountered, and is recorded because of reduction of the silver coating in direct ratio to the force delivered. The resistance is variable, and in the anatomical areas is dependent on the inorganic salt composition of the parts, the atomic weight of these salts and the density of their formation. A review of any analytical chemistry will indicate that there is a rather wide range of difference in the inorganic salts component of anatomical tissue. Bone, as indicated by the examination of the ash residue, has a 61.50 per cent inorganic residue, as against 0.88 per cent for the soft tissues. Of the two chief inorganic salt components of this residue, calcium oxide exists to about 28.55 per cent and phosphoric oxide approximately 19.55 per cent. The atomic weight of calcium is approximately 40.07 and that of phosphorus is 31.04, as indicated by the international standards of atomic weights of 1918. The difference of resistance, therefore, as it exists in these two chief grades of tissue, soft tissue and bone, as computed by the difference in the atomic weight of their two chief component salts is as approximately 1 to 70. Considering the density of the shadow representing that tissue with a minimum of inorganic

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salts as the indication of ray force penetration, it is 70 times that indicated in an area representing bone or with reference

compounded through the cheek. Illustrations of this character are an indication of the increasing of resistance to penetra-

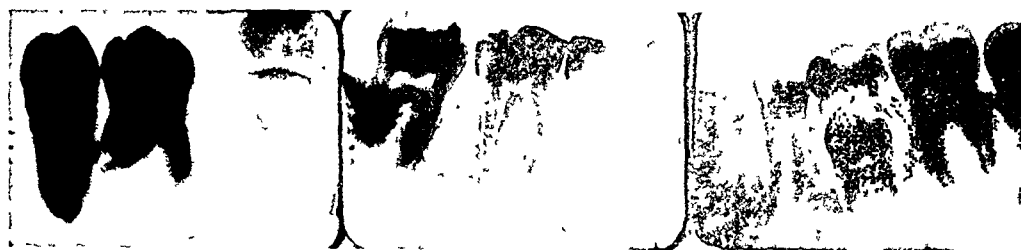


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 1. Two anatomical classes of shadow. From outline of finger-tip to outline of bony phalanx, smooth gray shadow area represents soft tissue with minimum of inorganic salt content, termed Grade 1 shadow. Within the heavier shadow outline representing phalanx there is another gray shadow, deeper in tone and rather mottled. Represents cancellous bone of Grade 11 a value. The two teeth are heavier gray or almost black, representation of heavier bone, and indicate Grade 11 b shadow. (Note: Shades reversed in negative.)

FIG. 2. Pulp chamber and root canals visible through tooth and bone structures. Note difference in outline of various pulp chambers. Pulp in first molar is putrid and because of lack of circulation in it, it is pictured sharply outlined in contrast to others, with circulation, which are in less sharp definition. Note filling (Grade 11 shadow) in second bicuspid with overhanging margin distally. Some Grade 1 shadow value to be seen between this filling and shadow of tooth structure. Indicates destructive process and in this instance decay. (Findings were shown to be correct after having been made originally from negative.)

FIG. 3. Normal distribution of Grades 1 and 11 shadow in jaw of a ten year old child with deciduous molar and unerupted bicuspid under it. Note Grade 1 shadow about crown of erupting tooth, which is a portrayal of tooth capsule of soft tissue. Note same character shadow about unformed root of erupting tooth, and similarly only to lesser degree about erupted bicuspid, which is not yet fully formed.

to the dental areas, the teeth, where we find the greatest concentration of inorganic salts of high atomic weights.

In the area recorded as soft tissue there is little definition and little change in the character of shadow possible except that of contour. A destructive process which would remove some of the inorganic salt content would allow the increase of force penetration to register to such an extent. This would be insufficient to develop any visible contrast. Because the density of the reduced silver coating in such a film area, a slight increase is harder to define than a corresponding decrease would be. A process however, of construction, growth, or deposit of greater inorganic salt content, if within the area of greater penetrability, becomes more easily definable. Note how easily the gingival ridge is portrayed in the edentulous jaw, and particularly so if this ridge is dense and fibrosed. Too, the wooden blocks, so often used to hold the dental film in place, can be defined and outlined over an area of gingival shadow, even

tion and varying the density of the film coating to a visible ratio.

To give a name and a classification to this type of shadow, I have termed those film densities which portray the soft tissues as Grade 1 shadows. This is in contradistinction to the shadow of bone parts with their greater inorganic salt content and greater resistance to roentgen-ray penetration, which is classified as Grade 11 shadow. It is obvious that there are two types of bone portrayed, the loose alveolar type or cancellous bone seen about the jaws, and in which the roots of the teeth are imbedded, which can be defined as Grade 11 a, and the densely compacted bone as represented by the teeth and the bone cortex, under the heavy periosteum, which may be termed Grade 11 b.

A study of the shadows thus classified would quickly indicate the anatomical tissue in which the portrayed and observed is generic. The anatomical position of any type of shadow is fixed. Its position and extent must be governed by the anatomical area portrayed, and so must

the ratios, therefore, of Grade I and II shadow correspond to the ratio of their normal existence in the area. Deviations must be recognized as the representation of the extent of any change taking place. The value of the alteration as a pathological entity must then be determined.

Without any history or clinical data, it falls upon the dental roentgenologist to determine first if there is or is not a lesion in the areas he is observing. Such determinations depend primarily upon experience, for without it he would not be able to recognize a normal portrayal of the parts and a proper ratio of the two chief grades of shadows. The intimate contact of the intraoral film with the anatomical part portrayed permits of the outline of the area in rather exact detail. This detail is so correct that it is possible to portray minor changes which take place with development, growth, and even such that occur within the tooth structure as the result of an alteration in circulation. It is obvious when referring to growth, that reference is not being made to deciduous teeth, but to growing teeth of the second dentition. Carefully made dental films as carefully read, should indicate such changes in tooth development as are compatible with growth, and differentiate such as are the result of some pathological process. These determinations are based on the known rate of development of teeth and the closing of the apical end of the root canals, as well as a knowledge of the size and shape of pulp chambers. It is an observation and interpretation made by virtue of the recognition of the normal ratio of Grade I and Grade II shadows.

In the dental areas there are often fillings in teeth and in root canals, which under certain conditions have no pathological significance, and at other times are the site or origin of the condition complained of. The majority of this reparative work is done with metals or metallic salts of high atomic weight. Their resistance coefficient is for the most part greater than is

that of dense bone. It is therefore necessary to consider a third type of shadow for this area. Grade III type of shadow embraces that of all character of filling material and is normally found within the tooth or within the root canal as filling material, or a replacement for a decayed portion of tooth. As a replacement, the filling material should restore the normal contour and the size of the tooth.

Each grade of shadow defined as visible in the dental area has its individual characteristics. Each has its anatomical position in which its portrayal will indicate its normal or pathological extent. With improper portrayal, each may be distorted. It is therefore necessary to understand the anatomy of the teeth and jaws, the variations possible within the normal limits and the changes due to normal development of the parts, or their alteration due to repair.

It is axiomatic that the finding of a shadow typical of a certain grade, in the position or of the shape normally that of another, calls for an explanation of the condition as either a normal process or a pathological lesion. Likewise, the alteration of the shape of a shadow in any grade of tissue, from that recognized as normal, must stand the question of its being a normal or abnormal one. To detail what type of lesion is responsible for a definite train of symptoms would require too great amount of space and too much time, but suffice it to say that the acute lesion is represented in Grade I type shadow, and is noted as an increase in the normal ratio of this grade of shadow over Grade II. Destructive lesions, such as infections, abscesses and cysts fall into this class. If one considers a lesion in bone (Grade II shadow), however, one has to deal with the destructive or osteoclastic lesion, where the process may be defined or identified as a replacement of Grade II shadow by Grade I or the proliferative or osteoclastic type of lesion in which Grade II shadow is made more dense. Osteoclastic lesions are usually found in the cancellous bone

areas, and here it will be noted that the shadow defined as Grade II a is assuming the density and characteristics of that of Grade II b. In shadow grades, this would be described as the displacing of Grade II a shadow by an increase in the extent of Grade II b for the normal ratio for the area. The chronic lesion is most often pictured as one indicating greater resistance to roentgenographic penetration. The 1 to 70 ratio in the soft tissue shadow is shortened, and in Grade II shadow the sharp normal outline characteristic of the parts is lost.

In this paper there has been no attempt made to point out characteristic lesions,

or to apply the rule of grading shadows here indicated, because of space. To give one's personal opinion as to the pathological significance of any finding makes for unnecessary controversy; therefore it will not be attempted. Suffice it to say that along with the recognition of shadows as to grade type and the placing of a resistance value on the reduced emulsion of the film, one must necessarily place a corresponding value in inorganic salt or mineral composition for the area. It is the determination of these as a correct and normal ratio which forms a basis for the determination of the possibility of a lesion and its pathology.



## ✓ CASE REPORTS ✓

### OPERATIVE REPAIR OF THE ANTERIOR CRUCIAL LIGAMENT OF THE KNEE-JOINT\*

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NEW YORK

THE symptoms of rupture or of attenuation of the crucial ligaments are primarily those of instability of the knee-joint. This may be a circumscribed instability referable to one or the other crucial ligaments. If the anterior ligament is frankly torn, there is increased anteroposterior mobility in extension; if the posterior, there is increased mobility backwards of the tibia on the femur, in flexion.

The classical circumscribed instability as outlined here and as originally described by Hey-Groves,<sup>1</sup> is not commonly seen. In my series of 8 cases, general knee-joint instability was pronounced in all but one, and the characteristic crucial instability was only a part of the general picture. In 2 of these cases, there was a frank rupture of the anterior crucial ligament; in 3 others, both ligaments were represented by very thin fibrous bands; in the remaining 3, marked attenuation and relaxation without rupture were encountered.

I conclude therefore that any knee-joint presenting the symptoms of chronic gross instability is likely to have crucial ligament damage, and that operative procedures which leave this out of account are not likely to be successful.

There can be no doubt that the crucial ligaments are torn in all complete dislocations of the knee, also that complete tears occur from lesser degrees of violence. The torn ligaments do not regenerate. Despite this fact, many such joints recover with good active but poor passive stability. The active stability is supplied by the

quadriceps extensor muscle and while the muscle maintains a high degree of efficiency, such joints are perfectly useful joints. Such cases are naturally not submitted to operation.

In this series, all patients gave a history of a moderately severe wrench of the knee-joint. In none was there a history of complete dislocation. All complained of pain. Several could not walk without a brace; others could get about without support, but had recurring falls due to giving way of the joint, and such cases had recurrent effusions. As already stated, all but one of these joints presented general gross passive instability with impaired active stability; the remaining case, reported later on, had good lateral stability, but had the characteristic circumscribed anterior mobility.

The technic of operation was described in a previous paper.<sup>2</sup> It is a combination of the Hey-Groves and the Alwyn Smith operation, but instead of the curved incision across the patella tendon, I prefer to open the joint medially by the incision I have described as the general utility incision.<sup>3</sup> A second incision is made on the outer side of the thigh, a long strip of fascia lata is turned down from above, remaining attached below. A hole is drilled through the external condyle of the femur into the intercondylar space, and a second one through the internal tuberosity of the tibia to in front of the tibial spine. The fascial strip is drawn through the drill holes from above downward, is sutured below the periosteum of the tibia, and the

\* Presented before the Section of Orthopedic Surgery, New York Academy of Medicine, February, 1930.

redundant portion of the strip is reflected upward to the internal condyle of the femur, thus reconstructing an internal lateral ligament.

Of the 8 cases, 6 have resulted in painless, stable knees with a full range of motion; one could be followed only ten weeks after operation, and had a satisfactory result for that time period; 1 was a failure, in that the disability was not relieved.

#### CASE PRESENTATIONS

(Three operated cases were demonstrated, the first having been operated upon in October, 1924, and reported in the paper previously referred to.<sup>2</sup>)

CASE II. S. F., aged eighteen, Hospital for Ruptured and Crippled, First Division. Twisted left knee three months previously. Recurring giving way and effusion since that time. Exploratory operation, February 19, 1927. Complete rupture anterior crucial ligament; an incomplete shelf across the quadriceps pouch, ending in a falciform edge.

*Operation:* reconstruction of the anterior crucial ligament by the technic described already; excision of the fibrous band in the pouch.

Discharged from hospital on the twenty-sixth day, walking with the aid of a stick. Full motion gradually returned without treatment. When seen in February 1930, he stated that he had had no further trouble, and that he had at various times played football.

CASE III. F. L., Aged twenty-six, U. S. Marine Hospital No. 43. One year previously slipped on wet deck and struck right knee. Immediately disabled. In hospital four months, during which stay the joint was aspirated, followed by physiotherapy. Went back to work for four months, but the knee was weak and unstable. It gave way again, and he was readmitted to hospital, where he had another period of physiotherapy, when he was seen by me after a four months' stay. The quadriceps was markedly atrophied, and there was general laxity of the joint including abnormal anterior mobility of the tibia on the femur.

*Operation:* exploration of knee December 5, 1929. Greatly relaxed anterior crucial ligament; adhesions between fat pad and head of tibia.

Excision adhesions, reconstruction of anterior crucial and internal lateral ligament. After four weeks, walking with the aid of a stick. In February 1930, about seventy-five days after operation, the knee was painless and stable, he had flexion to 90° and could go up and down stairs with ease.

#### REFERENCES

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2. KRIDA, A. The operative treatment of knee-joint instability following crucial ligament injury. *Internat. J. Med. & Surg.*, 1926, p. 179.
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#### DISCUSSION

DR. ARMITAGE WHITMAN: I wish to emphasize the point made by Dr. Krida, that even after the most successful reconstruction operation, as has been demonstrated by the examination of these cases, there is still abnormal anteroposterior mobility of the tibia upon the femur. The cases he has shown, however, have such well developed quadriceps muscles that they can compensate for the ligamentous instability. I think we should all do well to remember that stability of the knee-joint is dependant equally on ligaments and on muscles.

If we remember that fact we shall be spared much disappointment in what I call "fancy operations" on the knee, that is, arthroplasties and reconstruction of the crucial ligaments. Several years ago I did this operation on a German boy and, as far as the ligaments went, secured a result quite as good as any shown here. The boy's spirit had been so broken however by years of disability, false diagnoses and bad treatment that he could not be persuaded, forced or cajoled into moving his knee and thereby developing his muscles. I am thus not sure that he derived any benefit from his operation. Similarly, I performed arthroplasties on two girls, one Italian and one Austrian. Technically the operation appeared successful, but no amount of physiotherapy or occupational therapy would make them move their knees. They were finally discharged. The Italian girl appeared one day walking with a barely perceptible limp, with about 35° of motion. On being questioned she blushingy confessed that she was engaged to be married,

and did not wish her fiancé to know that she was lame. Shortly after the same miracle took place in the case of the Austrian girl. Her charitable uncle got tired of supporting her in idleness and she was forced to get a job.

I think that is a point of great importance in the selection of cases suitable for such operations, that the patients should have enough iron in their souls to develop the quadriceps muscle, which is, equally with the ligaments, responsible for the stability of the knee.

DR. BENJAMIN: Dr. Krida spoke of the suc-

cess of 6 out of 8 cases. I happen to know of one of these cases which was done some four or five years ago. After the operation this young fellow had a job as a radio repair man, and he fell off a roof and had some injury to his knee. Subsequently he fell off a horse, and was again injured but was able to walk after that. That seems to indicate that his knee was fairly well stabilized.

DR. KRIDA, *closing*: It is very important to select the proper patients for these cases. They should be under thirty years of age.



## OSTEOCHONDRAL FRACTURE OF THE KNEE-JOINT\*

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THE case here shown is one of a number of operated cases of fractures of the articulating surface of the internal condyle of the femur, commonly entailing as a late result the formation of free osteocartilaginous bodies in the knee-joint. The condition is commonly called osteochondritis dissecans. Since there is in these cases no clear evidence of osteochondritis, and since all those cases operated upon by myself were of definitely traumatic origin, I preferred the designation osteochondral fracture, as more clearly indicating their traumatic origin, and so described it in a previous paper.<sup>1</sup>

A. V., aged fifty, sea captain, U. S. Marine Hospital, No. 21.

*History*: Three months prior to operation, he fell from a height of 5 ft., striking on the extended right lower extremity. The knee became painful and swollen but he was able to hobble about. The pain and disability became gradually worse, so that his sleep was disturbed, and he lost 15 lb. in weight. He complains of a sensation of slipping on the inner side of the joint, and he refers his pain to that point.

*Examination*: He walks with the aid of a

<sup>1</sup> KRIDA, A. Osteochondral fracture of the knee joint. *Surg. Gynec. Obst.*, 39: 791, 1924.

\* Presented before the Section of Orthopedic Surgery, New York Academy of Medicine, February, 1930.

stick, evidently in considerable pain. The quadriceps muscle is greatly atrophied, extension is limited at 165°, flexion is possible to 80°. There is rather slight infiltration and no effusion. There is marked tenderness over the articular surface of the internal condyle when the knee is flexed.

X-ray films show an irregularly oval fracture of the articulating surface of the internal condyle. The fracture line is represented by a narrow area of rarefaction which has been accentuated artificially in the accompanying reproduction since it may be seen well only by transmitted light in the original films.

*Operation*: December 14, 1927. The joint was opened by the general utility incision. The middle of the weight bearing surface of the internal condyle presented a semi-detached fracture fragment  $\frac{3}{4} \times 1$  in. in size, and including about  $\frac{1}{8}$  in. of the underlying bone. This was removed; the rough edges of the remaining crater were smoothed off as well as possible with a chisel.

*Result*: His pain was relieved by the removal of the fragment. February 1930; range of motion complete. There is grating in the joint, and some discomfort after use, so that he has had to seek lighter employment. His symptoms have to a great extent been relieved, but those which persist must be ascribed to the location of the fracture directly in the middle of the weight bearing surface of the condyle.

## DISCUSSION

DR. HENRY MILCH: I am of the opinion that the type of osteochondral fracture due to a severe trauma is only one form of osteochondritis dissecans. Within the past three months, I have operated on a case which I consider osteochondritis dissecans in which there was a history of repeated minimal traumata. On opening the joint, found two osteochondral masses, but no concavity on the surface of either condyle from which they might have originated. The cartilage covering the articular surface of the femur gave the impression of having been moth-eaten, either as a result of the erosion caused by the joint mice, or as a result of the underlying pathological process which resulted in the formation of joint mice. I feel that this, too, is a case of osteochondritis dissecans, and that it should be included in the large group of osteochondritis dissecans which embraces as one type the osteochondral fracture which Dr. Krida has presented.

DR. W. M. BRICKNER: On various occasions I have advocated the treatment by aspiration of so-called traumatic synovitis. I have no doubt some of you have also used it instead of the time-honored strapping, bandaging and massage. I employ it in the smaller joints, e.g., the finger, the wrist; but, of course, especially in the knee. I have also emphasized the fact that the fluid at the outset of these cases is always blood or bloody, in other words, that we are dealing with an acute synovitis with a hemarthrosis; and, since there is blood in the joint, we must postulate a tear of the capsule to produce it, and some injury to a structure outside the capsule, ligament, bone or cartilage. Therefore one should have a more definite picture of traumatic synovitis in mind than that of a mere sprain. The injury is often an overlooked joint fracture that may not be seen even with ordinary x-ray examination. Sometimes, however, we will find a crack in the bone (femur or tibia) if the pictures are taken from various angles and with particular care to get bone detail. Also productive of traumatic synovitis is the condition Dr. Krida has described, osteochondral fracture, and this, too, occurs oftener than is generally recognized. I have in mind a case I operated on some time ago, a young man with recurrent effusions in the knee-joint following an injury sustained some months previously and with an x-ray finding similar to that shown by Dr. Krida. He, too,

had an osteochondral fracture of a condyle of the femur. When I opened the knee-joint and removed this fragment of bone and carti-



FIG 1. Osteochondral fracture.

I found another, unsuspected and very much larger fragment of partly attached condylar cartilage, a pure chondral fracture of the articular surface of the femur. There must often occur such chondral fractures or cartilage tears, in connection with traumatic synovitis. We can see roentgenographically the osteochondral fracture, since it tears off a bit of bone; the purely chondral fracture, however, is not shown in the x-ray film.

DR. KRIDA, closing: I agree with Dr. Brickner that some of the most striking cures can be made by aspirating the knee-joint in cases of hemarthrosis. On one occasion I was called to see a big man who had been lying in bed for three days unable to obtain relief from mor-



phine; he had hurt his knee, and by having the joint aspirated of about 60 c.c. of blood, he was entirely relieved.

As to Dr. Milch's remarks about these fractures, I did not mean to imply that there is no such condition as osteochondritis dis-

secans; it must be very rare; in exploring knee-joints I have never seen one that I could not attribute to traumatism. I have never seen osteochondritis dissecans non-traumatic. These fractures correspond in appearance to Koenig's description of osteochondritis dissecans.



## DISLOCATION BETWEEN FIFTH & SIXTH CERVICAL VERTEBRAE

### DELAYED OPERATIVE REDUCTION & FUSION\*

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NEW YORK

THE case here reported is one in which a successful outcome was obtained by open reduction and fusion of a grossly unstable fifth and sixth cervical dislocation, eleven weeks after injury. The possible failure to obtain and the obvious failure to maintain reduction are outlined in the recital of events prior to the date of operation.

*History:* A. H., aged forty-two, laborer. Forty-eight hours previously he was struck on the back of the head by a bale of hay falling from a loft in the barn. It was stated that he was immediately disabled and that he had paralysis of the extensors of the wrists and fingers, and of the biceps humeri on both sides, together with a feeling of heaviness in both lower extremities.

I was asked to see the patient at the request of an insurance company in consultation with his attending physician at a hospital in the country. He had at this time no paralysis, but weakness of the extensors of the wrist and fingers, and a very much increased knee-jerk on the right side. He was in great pain and his neck was rigid. The x-ray showed a nearly complete forward dislocation of the fifth upon the sixth cervical vertebra.

*Operation 1.* Closed manipulation. The patient was removed to the operating room. Traction apparatus was improvised, and the patient was anesthetized with ether. Traction was applied to the head with an improvised portable Hawley apparatus, the head straps

being fastened to a single foot stirrup, and counter traction by a surcingle over the iliac crests reinforced by manual traction on the lower extremities. After fairly considerable traction had been applied, there was a coarse bony click. The traction on the head was then maintained manually and a plaster of Paris dressing was applied including the chin and occiput and extending to below the nipple line.

The patient was not again seen until admission to Hospital for Ruptured and Crippled five weeks later, and details of his stay at the country hospital include an x-ray picture taken through the plaster collar which was reported upon as indicating that the dislocation had been reduced. Without advice the collar was removed at the end of three weeks since there was no evidence of paralysis at this time and patient allowed to sit up and move his neck about. At this time an x-ray was made which, much to the astonishment of the attending surgeon, showed that the dislocation has either recurred or in the initial instance not been reduced.

November 9, 1928. Hospital for Ruptured and Crippled. There was no pain, paralysis, or gross external deformity. The x-ray showed a remarkable degree of dislocation at the junction of the fifth and sixth cervical vertebrae. The dislocation of the fifth body was of a degree where its posterior border impinged just behind the anterior upper border of the sixth. There was also an angulation at this point in which the upper part of the spine was angulated forward on the lower. There was no evi-

\* Case reported and x-rays shown before the Section of Orthopedic Surgery, New York Academy of Medicine, February, 1930.

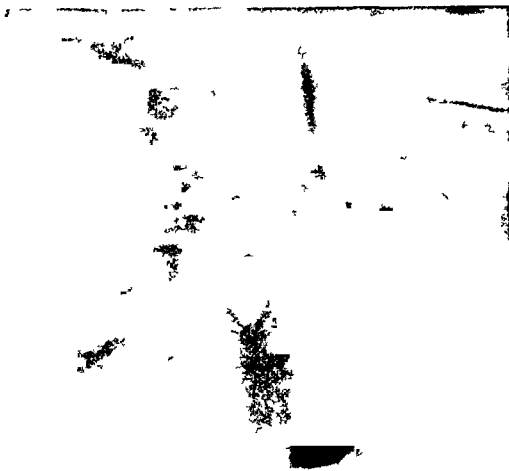


FIG. 1. Condition five weeks after injury.



FIG. 3. Recurrence of deformity in Calot jacket.



FIG. 2. Reduction of deformity by traction on convex stretcher frame.

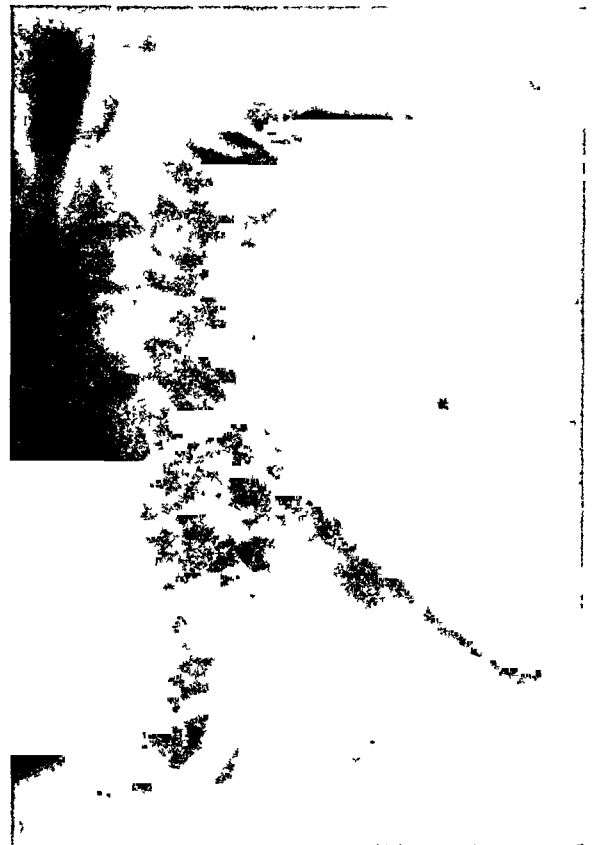


FIG. 4. Solid fusion with slight deformity six months after open operation.

dence of gross crushing or of fracture of the laminae.

He was placed on a convex stretcher frame and traction was applied to the head. After one week an x-ray showed a marked reduction in the deformity. After three weeks of traction a Calot plaster of Paris jacket was applied under suspension. Five days later an x-ray was made through the Calot jacket, which showed that the deformity had recurred to substantially the degree present on his admission to hospital. This indicated that there was no stability in the operated area, and he was prepared for open operation.

*Operation 2.* December 11, 1928. Operation for dislocation of the cervical spine. A long median incision, the patient's head resting in a special head rest so arranged with a traction band so that traction could be made during the operation, the band being placed around the waist of an assistant. The spinous processes and laminae were exposed beginning at the first dorsal vertebra and working upward. It was found that at the junction of the fifth and sixth cervical vertebrae, the upper ones were displaced forward and flexed to a fairly remarkable degree, the distance between the lamina of the sixth and that of the fifth being fully 1 in. and the forward displacement in this plane being about  $\frac{1}{2}$  in. The laminae of

the fifth, fourth and third were carefully freed and exposed. Then by combination of grasping the lamina of the fifth and levering on either side between the articular facets and by traction on the head, the fifth was gradually mobilized and drawn backwards on to the sixth. At the termination of the mobilization and reduction and upon releasing the traction on the head there was a fair tendency for the bones to remain in place. Fusion between the fifth and sixth was then done by the Hibbs method, turning up bone from both laminae and erasing the joint, splitting the spinous processes and utilizing as re-enforcing material the split spinous process of the seventh cervical vertebra. The incision was closed and the previously prepared plaster of Paris Calot collar was applied.

The postoperative x-ray showed that the dislocation had been reduced. The patient was discharged from the hospital at the end of six weeks, wearing a Calot collar, for which a leather Thomas collar was substituted after one month. All support was removed at the end of five months.

August 31, 1929, eight and one half months after operation, the x-ray shows that the fused area is solid, and that there is but slight deformity.



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## EDITORIALS

### FRACTURES AND MODERN HOSPITALS

THE recent visit of Prof. Lorenz Böhler of the Unfallkrankenhaus, Vienna, to demonstrate his methods in the treatment of fractures has its significance at this time. It serves to emphasize the growing importance of fracture treatment in this country and abroad and gives us the opportunity to measure his standards to ours and to determine wherein our methods can be improved. His visit comes at the opportune moment when this question is receiving serious attention from both the medical profession and the laity. His visit should be profitable to us as he has brought fresh views on the subject and has enlightened us with authoritative information on the progress that has been made in Europe.

The addresses he delivered before the American Orthopaedic Association and

the American Medical Association were impressive to say the least. Many features of his method are novel in their application although not entirely original in their conception. The general use of local anesthesia, extensive use of axial bone traction and the unpadded cast all have a place in the modern treatment of fractures but their application to the methods that prevail in this country should be governed by good surgical judgment and expediency. Time, patience, and surgical skill will define their true merits but with the information now available there is every indication that the methods he advocates will find a permanent place in our treatment of fractures.

He has given ample demonstration of the outstanding principles of his treatment but to fully appreciate his success one must

visit the institution for first-hand information of his methods and organization. It becomes apparent above all else that *the hospital is the proper and logical place to undertake the efficient treatment of fractures* with the possible exception of minor bone injuries that can be treated at home. The success of Böhler's treatment at the Unfallkrankenhaus is measured in terms of surgical skill, equipment and organization, each receiving proper emphasis but with correct balance in functioning as a whole. The standards he sets for us would require the establishment of a special hospital devoted to the treatment of fractures, with full-time assistants, highly trained and efficient in the specialized care of bone injuries. The extent to which we may follow his example remains to be determined but from the knowledge gained by his demonstrations in this country there appears to be little doubt that the present hospital methods of treating fractures have not maintained the high standard of efficiency evident in other branches of surgery. In a measure this is the fruit of Böhler's message and if we are to profit by his example we must take cognizance of our omissions in so far as our hospital methods are concerned.

The modern hospital aims toward perfection of organization, specialization and standardization and without these standards of efficiency it cannot keep in step with progress. We have come to an awakening in regard to the treatment of fractures which, in a measure, has been forced upon us by the throbbing, pulsating everyday life that has grown up outside the hospital. Industry, traffic and even our methods of living are being constantly standardized, specialized and ever moving forward. The modern hospital plays a vital part in this complex social order and no effort of ours should be spared to maintain the high standards that are expected of us. Advances in medical science are not solely due to our professional initiative. They may reflect progress that originates outside our field of science. They may even bow to

the demands of other influences that momentarily outstrip us in the march of progress. A demand has already come to us for improvement in our methods of treating injuries. The patient, the employee, the employer, society and industry in general call upon us for better service, better time-saving methods, more efficiency, and greater skill to minimize the devastating effect of fractures to society and industry. This demand upon the medical profession must be and will be seriously and efficiently met. There is no question of personal service involved for that has been the profession's greatest attribute. There is no question of knowledge or of skill as they are amply demonstrated in almost every other field of surgery.

We may ask ourselves why this is true of the treatment of fractures while other branches of surgery have advanced far beyond. The answer must be apparent to those who seriously seek the facts. Let us call it a state of mind into which we have allowed ourselves to lapse without fully realizing that we have ceased to progress. We have in a sense been standing still in our *methods of organization* for the treatment of bone injuries.

The remedy is within our reach and it requires but the effort to grasp it. The modern hospital is the place to initiate the organization for the treatment of these injuries as it is the immediate point of contact with the injured. Let us apply our standards of organization, specialization and standardization to the treatment of fractures as they exist in general hospitals today and determine wherein we have failed to measure up to the high ideals and humanitarian motives that guide us in our life of service to the patient.

To a small group of surgeons specialization in the modern treatment of fractures is an accomplished fact and the character of their work is worthy of the highest commendation. To many more it is still an ambition while the rank and file who have not as yet given serious thought to

the subject still adhere to the belief that the clinical surgeon is fully capable to treat all fractures as part of the general practice of surgery. Faith in this belief is rapidly waning as the extent and character of the advances in this field of surgery are more generally known. Doubt casts a glance at this belief of surgical efficiency and further speculation might even question the proof of this claim. Compensation bureaus and industry have already offered facts to the contrary and measures have been suggested to meet the situation. While the treatment of fractures has failed to assume the commanding position it deserves there has developed a serious situation that vitally affects the interest of the profession due to the surgeons lack of understanding of its scope and magnitude. Commercial agencies are already knocking at the doors of our hospitals for the privilege of treating fractures with special patented devices and even furnish the necessary service for their application for a fixed minimum charge to the patient.

Our efforts must be devoted to furnishing the patient with the most efficient service and to restore him to health in the shortest

possible time. The present organization for the treatment of fractures leaves much to be desired and very radical changes may be required before our surgical initiative has been re-established. Let us seek and welcome more surgeons with messages like Professor Böhler's and let us stir ourselves to greater efforts to maintain the high standard of bone surgery that has been associated with the names of countless number of American surgeons whose achievements are an inspiration and a source of just pride.

Professor Böhler returns home with our sincere expression of appreciation and hearty commendation for the excellent work he has performed in his special field of surgery. He has been a perfect guest. He has done the things we wished him to do and he has told us the things we wished to know. He has been untiring in his efforts and gracious in his manner and we sincerely hope and trust that his first visit to this country has been a happy one that will furnish him pleasant memories and lasting friendships but that it will be the forerunner of many others of a similar nature.

WILLIAM G. DORAN, M.D.



## MEDICAL TEACHING

WALTER Alvarez has just had published a most interesting and instructive book on "Nervous Indigestion."<sup>1</sup> We take the liberty of quoting from parts of his Preface. Some months ago John Osborn Polak wrote an editorial on *The Clinical Teacher*.<sup>2</sup> It caused widespread comment. We received scores of letters, most of them approving Dr. Polak's stand, which made us think this subject is a live one in the minds of many men.

<sup>1</sup>Dr. Alvarez' book, "Nervous Indigestion," is reviewed under Book Reviews in this number of *THE AMERICAN JOURNAL OF SURGERY*, p. 578.

<sup>2</sup>*AM. J. SURG.*, 7: 723, 1929.

Thus, while reading the preface to Alvarez' book we could not refrain from marking parts of it. Without further editorial comment we will quote the paragraphs checked by us. The reader may draw his own conclusions.

As time goes on it seems probable that most teachers of medicine will step directly from the laboratory into the professional chair, and as a result there will be fewer and fewer of them with any knowledge of medicine as it is practiced in a downtown office, with patients from the middle and upper classes. This will be unfortunate because most of the students in

our universities are going out into private practice, and I think they should be prepared for the fact that they will meet with human beings and problems different from those encountered in clinic and ward . . . It seems to me as time goes on more provision will have to be made for acquainting medical students with the problems that they are going to meet in practice . . . I doubt if teachers of medicine realize how seldom it occurs to them to spend an hour in the amphitheater talking about

"functional" disease . . . If these conditions continue I fear that every year more and more students will graduate from even our best universities well equipped with information about the rarer diseases, which they will seldom encounter, and woefully unprepared to deal with the functional troubles which they will see several times a day. Furthermore, they will have learned much of the science of medicine but little if anything of the art.

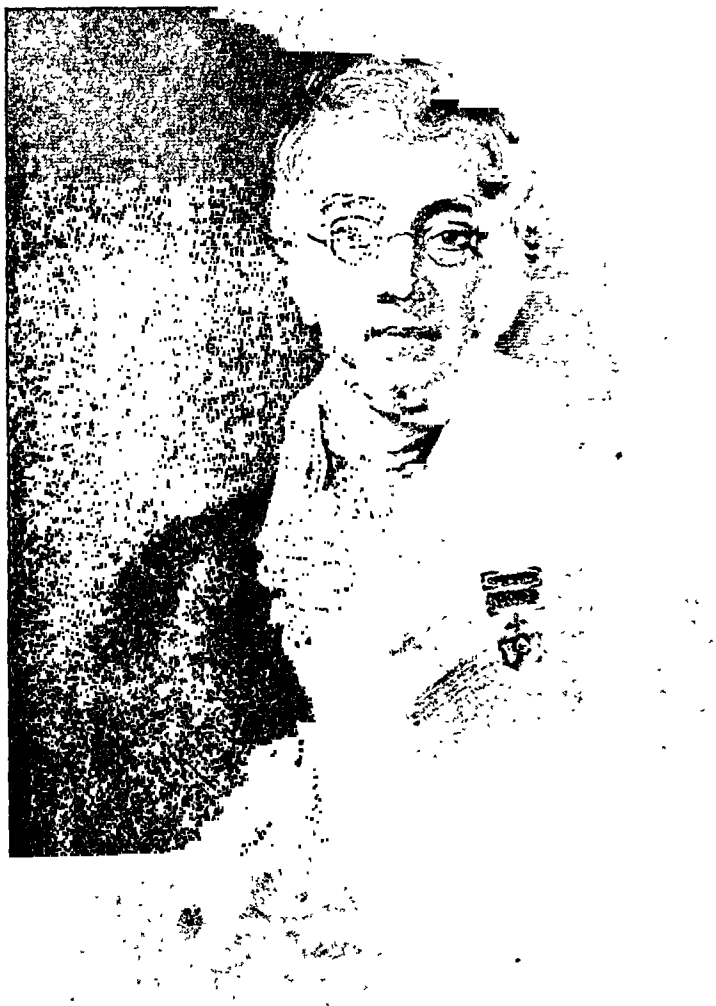
T. S. W.



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SIR CHARLES BELL

[1774-1842]



## "BELL'S PALSY"

**A**N artist of ability, an anatomist of distinction, a surgeon of rare skill, and a man popular with his professional colleagues and society, sums up the character of Charles Bell.

He was the son of a Scotch Episcopal clergyman. John Bell, a surgeon of reputation, was his brother.

Charles journeyed to London in 1804. He opened classes for the teaching of anatomy at his own home and later at Great Windmill Street. In addition he gave courses of lectures to artists. The result of these lectures became embodied in his "Anatomy of Expression" (1806).

Because he devoted the major part of his time to private investigation he had little time to acquire a private practice. In the end he accepted the chair of surgery at Edinburgh in 1836. What the laymen of London missed was more than supplemented by Bell's achievements of a scientific nature.

Bell illustrated his "System of Dissections" in 1798. He did "Engravings of the Brain and Nervous System" in 1802. His Bridgewater treatise on the hand, done in 1833, is remarkable because of his exquisite sketches. In 1811, he published "A New Idea of the Anatomy of the Brain and Nervous System." In this work one finds an epoch-making sentence.

On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves which took its origin from the posterior portion of the spinal marrow

without convulsing the muscles of the back, but that, on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.

So we have the first recorded experimental reference to the function of the spinal cord in literature.

Although Bell made many discoveries he had a dislike for vivisection. Therefore, he failed to interpret many of his findings. For instance, it was left to Magendie in 1822 who used a litter of pups to find that the anterior roots are motor and the posterior roots sensory.

In 1829 he demonstrated that the fifth cranial nerve is sensory-motor. At this time he discovered "Bell's nerve." We refer to "Bell's palsy" from his discovery that a lesion of the portio dura of the seventh nerve causes facial paralysis. He incorporated all these discoveries in a book on the nervous system in 1830. This work contains early reported accounts of pseudo-hypertrophic paralysis and "Thomsen's disease."

Bell was in his day known as a dandy. By nature genial and sociable he was much lionized by London society. In 1829 he was knighted for his physiological discoveries. We read that as a surgeon he attended the wounded after the battles of Corunna and Waterloo, and left many interesting sketches of the things he saw.

All in all his was a full and interesting life. Born in 1774 he died at the age of sixty-eight years in 1842.





[From Fernellius' *Universa Medicina*, Geneva, 1679.]

# BOOKSHELF BROWSING

## SOUVENIRS OF MEDICAL REGISTRATION IN FRANCE\*

THEODORE C. MERRILL, M.D.

PARIS, FRANCE

THIS account presents experiences which depart but very little from those which must be encountered at the present time by any foreign candidate for official medical practice in France. The viewpoint represented is, naturally, mainly an Anglo-Saxon or American one and the coloring is possibly not the same as would be the case were the reporter a Latin, Oriental or Slav. However, the procedures themselves are alike for aspirants of any race or nationality.

### FRENCH MEDICAL DIPLOMAS

All courses of study offered in the French universities of the capital and provinces are practically parallel and uniform, being prepared and formulated by the central Ministry of Public Instruction. Differences are due principally to variations in the extent and variety of clinical material. Mainly for this reason, the Faculty at Paris is considered the most important of the French medical teaching groups. However, the Faculties at Strasbourg, Lyons, Marseilles, Montpellier, Bordeaux and Lille are also of high excellence. Because of the centralization and uniformity prevailing in the French educational system, diplomas granted by the medical faculties of all the French universities enjoy equal

ity of official recognition and confer equal rights upon those possessing them.

The French faculties award diplomas of two kinds. First, they may grant the *diplôme universitaire*. This diploma is awarded to persons desiring a formal French certificate or diploma, referring to general medical study (as contrasted with limited and special post-graduate work) and serviceable at home or abroad as evidence of study done in France. This diploma does not entitle its possessor to practice medicine in France or the French colonies. It is obtainable by physicians who are graduates of acceptable medical schools, provided the candidates pursue the regular undergraduate medical courses of at least the last two years, perform the accompanying work in hospitals and laboratories, pass the regular didactic and clinical examinations and present and defend the thesis which is invariably required. Aspirants for the "*diplôme universitaire*" are not obliged to obtain the French academic baccalaureate degree or the so-called "*P.C.N.*," a certificate showing one year's work in physics, chemistry and the natural sciences.

For the right to practice medicine or surgery in France, the *diplôme d'état*, or official state diploma, is absolutely

\* Submitted for publication April 10, 1930.

necessary. It is granted with the legal proviso that candidates for it must possess the French baccalaureate degree and the P.C.N. certificate just mentioned, must complete at least the two final years of the regular medical curriculum, must pass the examinations on the work of these two years and the final clinical tests in medicine, surgery and obstetrics, must fulfill the hospital work or stages accompanying the two years' medical study and must present and defend an acceptable thesis.

Requirements for the *diplôme d'état* are thus exacting. They allow no credit for previous college or university work abroad, except that they omit, for physicians of good standing in their own home countries, the first three years of the regular medical curriculum and do not actually insist on the year's work for the P.C.N. certificate. For once this diploma has been obtained, the shortest possible period of study ranges from four and one-half to five or more years, according to the candidate's facility in doing the baccalaureate work, passing the medical tests and completing the thesis. Such was the program followed very literally by the writer when engaged in solving the problem of entering upon medical practice in France.

#### THE BACCALAUREATE

This degree roughly corresponds in scope to the work of the first three years in American colleges for the A.B., PH.B. or B.S. degrees or their equivalents. It may be obtained either before or after completion of the medical work. The writer attacked it before.

In a naive hope that fairly fresh remembrance of former college work done in the United States might be sufficient, the examination for the first part of the baccalaureate was rather rashly attempted in the autumn, after a rapid review of only some three weeks. The natural, and instructive, result was failure, to an extent which showed, however, that success might

not be impossible with adequate preparation.

The studies for the baccalaureate may refer either to sciences, languages and literature or to sciences and mathematics. The writer chose the former group, or *Latin-Langues*, the second group requiring mathematics extending well beyond mathematics given during the freshman and sophomore years in American colleges. The necessary preparation was directed by a competent private French instructor. The writer was thus classed as an *élève libre*, or free student, as contrasted with a student attending regularly outlined courses in a French secondary school, or lycée. Instruction may also be sought at various schools which advertise more or less widely. These schools, however, of commercial type, are graphically known as *boîtes à bachaut* or mere *baccalaureate boxes*, and I believe that the study which they supply is too summary and rapid for foreigners and not solid enough to give the foreign student much assurance of success in passing the official examinations. The *boîtes à bachaut* are bad enough, even for native French students.

The writer's instructor gave a weekly lesson of two hours' time. It dealt with a variety of subjects. The weekly lessons were continued without a break during the two-year period devoted to the baccalaureate, obtained after passing the regular examinations at the Sorbonne.

The first-year subjects were French composition, the drill referring to French history and literature; general history of the eighteenth century, Latin, geography, and mathematics through solid geometry. For the second year, the studies were in philosophy, the authors selected being Descartes, William James, Claude Bernard, Ribot, Janet, Bernstein and others; general history of the nineteenth century, German, English, physics, chemistry, mathematics, botany, zoology, elementary human anatomy and physiology and a continuation of French composition, devoted mainly to philosophical and psycho-

logical material. In the *Latin-Languages* course mentioned, two foreign languages are required, those of the writer being

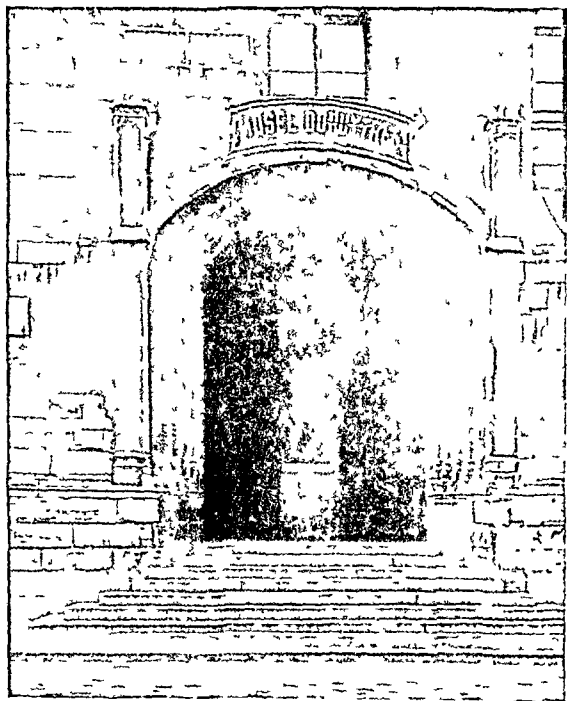


FIG. 1.

English and German, the native language supposedly consisting of French.

Intensive review and study are necessary for confronting the examinations for the baccalaureate, especially if the candidate is not freshly familiar with his material. Such review is important, even if the material is more or less familiar, because it presents new viewpoints, promotes good knowledge of French and brings out peculiarities inherent in French examinations and the presentation of the subject-matter. French standards are strict. However superfluous some methods may seem, they must be complied with. Conventions must be respected. In academic tests, original theories or opinions are neither desired nor accepted. Discussions should avoid reference to religious, military, political or other points of acutely present interest or controversy. The examinations are designed to show the candidate's accomplishments in the prescribed educational program. The latter, by the way,

is so uniform throughout France that it is often said, and without too much exaggeration, that instructors know, at any given moment, precisely what page in any subject is being studied by all the students of France of the corresponding grade.

During his training-period, the writer referred, in a certain composition, to Poincaré, Marshal Foch and the French President. The instructor raised both hands in shocked protest. "Never," said he, as he vigorously scratched these names, "never discuss, for such an examination, anybody who hasn't been dead for seventy-five years at least!" Introduction of personal or controversial views into French examinations is sometimes very disastrous.

#### BACCALAUREATE EXAMINATIONS

At the close of the first study-year, a *convocation* or summons, was received by mail, due application for registry in the yearly examination having been filed two or three weeks before, on officially stamped paper, with presentation of birth certificate. The writer's convocation was worded as follows:

"Université de Paris, Faculté de Lettres; Baccalauréat Latin-Languages, First Part. No candidate will be admitted without his receipt for the examination charges. Written examination 7 A.M., July 12. Oral examination 2.30 P.M., July 18. Only candidates succeeding in the written tests are admitted to the oral examinations."

On the morning of July 12, then, the author joined a throng of young men and women, aged, in general, from sixteen to twenty, who were surging through the corridors of the Sorbonne in search of the amphitheatres to which they had been assigned. The young folks' faces were grave, and so were those of the parents and friends who accompanied them, for failure here means the loss of a whole year, or at least painful drudgery through the summer for supplementary examinations held in October.

Doors were not opened until about

eight o'clock. The students then filed into rooms full of separate desks and tables. Each student deposited his *livret scolaire*,

written tests occupied two days. No marks were immediately furnished, the students remaining ignorant of success or



FIG. 2.

or record book, signed by the school or instructor who had prepared him, submitted his fee receipt and received a number. The questions were read aloud. Should a student fail to understand, he may ask to see the printed slips bearing the questions. These slips are in the hands of the examining officer. That it is well to be sure of the questions is proved by two curious errors recently committed. On these occasions, subjects allotted for discussion were the following: "Victor Hugo sera lu, mais en anthologie [Victor Hugo will be read, but in anthologies]" and "Hygiène de la mémoire [hygiene of the memory]." Two respective students understood the examiner to say, "Victor Hugo se rallumait en entrant au logis [Victor Hugo grew light-hearted on coming home]" and "Hygiène de la baignoire [hygiene of the bath-tub]." The papers of these two unfortunates were marked zero in the subject of literature.

A choice between several groups of questions is usually offered. Writing-paper is the only material supplied by the authorities, and waste of it is not welcomed. The

failure until the moment of the oral tests. With these, the anxiety of the assembled students seemed even greater than before. Not until the hour set for the orals did monitors appear, posting lists of those who had passed the written examinations and who might, therefore, be admitted to the oral ones. As the students crowded forward to read these lists, painful indeed was it to remark the disappointment of those who had failed and to read the downcast faces of their parents and friends as they and their unlucky candidates turned sadly away from the Sorbonne battleground, either to face still further preparation or to give up the struggle for a technical career. Failure is, of course, still possible for students admitted to the orals.

The examiners constitute a species of jury and are known as a jury. Each member presides over his own special subject and the students appear before him one by one. At the close of the test, the grades obtained by each student were read aloud to all and the students were then dismissed in a few gracious and kindly

words uttered by the President. Each student recovered his *livret scolaire* before leaving the room, and the first part of

question of influence, "pull," or *piston*, as the French call it, in its relations to the abbreviation of requirements. I may



FIG. 3.

the examination for the *bachaut* had become a thing of the past.

The second part was completed in similar fashion. At the oral test, the professor of history was intrigued by the appearance of an evidently older (and foreign) student among the young stock, but exchanged cards and courteously invited the stranger to make his personal acquaintance and wander now and then through sections of Old Paris, dear to the historian's heart. This was one very charming and lovely fruit of the baccalaureate inquisition.

A provisional diploma was received some two weeks after passing the oral tests of the second part of the *bachaut*. The final official document was not received until a year or so later. Delivery was slow because of scarcity of university funds and personnel, in evidence ever since the difficulties of the war. The provisional diploma served for presentation when applying for medical enrollment.

#### MEDICAL ENROLLMENT

Here I obtained first-hand information concerning the interesting and important

as well say at once, bluntly and frankly, that it is better to depend solely upon oneself and to disregard all advice counselling the application of *piston*. Formal regulations, of which printed copies (such as the *Livret de l'Etudiant*, published by the Presses Universitaires) are available at the medical bookstores, clearly indicate the necessary procedure. Pull may work well, or may have worked well, in certain cases but it did not with me and it is not generally effective, its relation to my own case being illuminating enough to justify a tale of my experience.

When I was about to enroll, certain friends advised me to utilize the services of friends of friends who were in official employ. It was not easy to refuse these well-meant offers and letters of recommendation were accordingly placed in the hands of a member of the Ministry of Public Instruction. This official directed me to file my papers with his attorney, who showed me how to fill out an enrollment form and then lapsed into silence. The silence continued darkly, even after October arrived and the opening of the

medical courses became imminent. My sponsor then proved to be absent on his vacation and I had to act immediately. I hastened to the attorney, paid him a respectable fee for very little assistance and was obliged to withdraw my papers from him and present them myself to the secretariat of the Faculté de Médecine.

My letters and other papers were transmitted thence to the appropriate Faculty committee, but were returned to me without the slightest sign that they had even been opened. They were ignored, in fact, because of the attitude of the French Syndicat des Médecins, or physicians' union, which actively safeguards French medical practice and practitioners, as it should do in order to prevent overwhelming of the French profession. The delay incurred by my attempt at "pistonning" retarded my hospital registration and I had to make up the lost time during the Christmas vacation. In fact, I was just able to complete my first hospital stage on time and narrowly missed losing two months. It would have been far preferable to act directly.

After I had enrolled for the medical work, the required P.C.N. certificate proved to be obtainable *à titre onéreux*, which means that it would be granted me on payment of the customary fee, with absolute exemption from the extra year of work represented by it. This concession was, naturally, welcome. The principle of common sense was here delightfully given full play. With the baccalaureate diploma and the P.C.N. certificate, medical enrollment could proceed without difficulty, save with respect to the afore-mentioned tardiness in arranging the first hospital stage.

Each medical student is supplied, on enrolling, with a *livret universitaire*, a counterpart of the undergraduate *livret scolaire*. It contains his photograph, registration number and blank pages for recording his examination grades. The *livret* must always be presented to examiners, who enter within it the grades which they

grant. When completed, this little book constitutes a record of compliance with regulations, of the marks obtained and of the grade accorded the student's thesis. It is finally retained by the student, whether he succeed or fail.

#### THE MEDICAL PROGRAM

The foreign candidate for medical practice in France is now confronting his last two years of the regular five years of the French medical system, his laboratory and hospital requirements, his coming didactic and clinical examinations, and his thesis.

*Didactic Work:* No attendance on lectures is required. The student is free to do as he likes in this respect, just as he is free to study or not. However, attendance at the faculty lectures is of supreme value and importance, especially for foreign students. Faithful attendance alone permits a knowledge of technical terms and of French methods of presenting written material, for examinations and other purposes. It is invaluable for such work as prescription-writing in French. Again, it is practically indispensable in preparing for the more difficult examinations, such as the tests in therapeutics, which are a special *bête noire* even to the French students themselves. For the examinations, lecture-attendance is highly useful, from the viewpoint of matter as well as that of manner. Foreign students who fail to attend all lectures bearing on the curriculum seriously handicap themselves. The regular French students generally permit themselves no such handicap, as proved by the crowded amphitheatres.

Nor is immediate utility all. It is not too much to say that many of the lectures given gratis at the University of Paris, and at other French universities, have no superiors in the world for brilliance, precision and charm. Seldom has the writer listened to expositions so clear, forceful and beautiful, and so full of learning, wit, humor and pure delight. Among those who eagerly seek places at these lectures are



not only undergraduate medical students, but physicians, surgeons and technicians of every race and language. Places are decidedly at a premium in some of the lectures. At those on therapeutics, given in the large amphitheater of the Paris faculty, every place was always filled and "standing room only" awaited late arrivals. In my own case, desiring a seat where I could hear clearly and have a good view of blackboard notes, it proved necessary to appear fifteen minutes before the opening of the lecture. The few inevitable departures from this practice were always deeply regretted.

*Laboratory Work:* The required laboratory work, much the same from year to year, refers to pharmacology, medical chemistry, pathology, study of sections, legal medicine and toxicology, and hygiene. An optional course, of decided value, is given in prescription-writing and is of special utility for those intending to practice medicine in France or the French colonies. The work in the subjects just mentioned comes during the last two years of the medical curriculum, other laboratory work being also included in the first three years of the regular medical program.

*Hospital Stages:* Regular daily hospital attendance is insisted on from the beginning of the French medical training. In my case, the required work progressed chronologically as follows, each period or stage, being of two months, except in the subject of obstetrics, in which three months constituted the period: infectious diseases, at the Claude Bernard hospital, used for isolation; dermatology, at the Hôpital Saint Louis; neurology, at the Salpêtrière; obstetrics, at the Hôpital Boucicaud; psychiatry, at the huge asylum of Sainte Anne; ear, nose and throat, at the Hôpital Lariboisière; ophthalmology, at the Hôtel Dieu and urology, at the Hôpital Necker. The professors in charge were, respectively, Teissier, Jean-selme, Guillaïn, Le Lorier, Claude, Sèbilleau, Terrien and Legueu.

In the hospital stages, attendance is

usually checked by roll-call and record. At the Claude Bernard hospital, the students had to sign one roster at the beginning and another at the end, of each morning's work. Absences count seriously against the student if they are detected. Each stage must be marked and certified by the professor or *chef de clinique* in charge before the student can be admitted to the next stage in his program. Quizzes are held more or less regularly. Lectures and various demonstrations are given during the stages. The student should familiarize himself, by outside reading and study, with the pathology and therapeutics applicable to the given stage which he may be pursuing.

*Final Examinations:* These are of two kinds. First, there are those held at the close of the required subjects. These are generally oral, but the examination in therapeutics usually includes a preliminary written test. If this is passed with a grade of 70 per cent or over, the candidate is excused from the oral examination. The less well prepared students are thus confronted with two examinations in this subject.

The oral tests are interesting and, for some of the students, fearsome. However, they are perfectly fair and students who cannot satisfactorily answer the classical questions put to them may be safely considered incompetent. The jury system prevails. The student usually finds three professors in charge of the examination. Interrogated according to lists held by the examiners, each student appears before one of the three. There can be no question whatever of favoritism, for the students are examined in alphabetical order and assigned to the different juries only on that basis. Indeed, the student and his examiner will never have met before, unless some chance has brought the student into contact with the professor during a preceding hospital stage, or unless the student may have seen the professor from afar during some lecture given by the professor. In practice, examiners are nearly

always without the slightest acquaintance with the students who appear before them.

Arrived before the examiner, the student replies to one or two perfectly fair questions. If the reply shows sufficient proficiency in the given subject, the examiner writes in the student's "livret" the grade obtained and the student is replaced by another. The grades are *très bien* (roughly 90 to 100 per cent), *bien* (80 to 90 per cent), *assez bien* (70 to 80 per cent), and *passable* (60 to 70 per cent). Should the student fail to satisfy the examiner, he is referred to a second one and may even have a third try. However, reference to the second examiner means still more searching questions and augurs ill for the student.

All examinations are public. Any who desire may remain until the last student has been examined. Students and others present then leave the room to the jury, who consult, more especially on students of doubtful attainments. After the jury have completed their deliberations and departed, the *garçon*, or aide, distributes the students' record books, or *livrets*, and often reads aloud the marks received. Low marks elicit sympathy and complaint, while high marks are greeted with cheers and felicitations.

A second variety of examinations is constituted by the final clinical tests in medicine, surgery and obstetrics. They may be attempted whenever the student is ready for them, and in any order preferred, after due application. A few days after the first test has been applied for, the student's name appears listed on the Faculty bulletin board. Each student makes one of a small group assigned to some hospital with which no student of the group is supposed to be familiar.

The clinical tests are not always easy and are a source of more or less anxiety, though well-prepared students have little to fear. On arriving at the hospital, the group is taken in charge by the professor or other responsible chief. To each student

is assigned a case, taken haphazard from the wards. About fifteen minutes are allowed for examination, diagnosis and outline of the indicated treatment. The student makes his record in writing, seals it and hands it to the medical officer in charge. On the next day, he undergoes a similar test at another hospital, his second case naturally differing from his first. Each examination, medical, surgical or obstetrical, thus includes two cases. The two clinical examinations in each subject are given rather early in the week and on the following Saturday the student repairs to the medical school, where the physicians in charge of his group assemble to form the usual jury. The sealed envelopes are then opened and the student discusses his case and his records, the interrogator being familiar with the case. If the discussion and record are satisfactory, the mark received is inscribed in the *livret* and the student is dismissed with kindly words. Each student thus appears before at least two professors and may be assigned to a third if his status seem doubtful. The professors are frank and outspoken, though by no means finicky or unjust. "Eh bien," remarks one, "don't look at me, look at your paper. You can't read the answer in my face." "Why do you prescribe that?" asks another. As the student stammers that his choice was made on the basis of home practice, the professor rejoins, "Remember that this is Paris, not Uruguay!" "Why," exclaims a third, "you don't seem to know much about this. Just describe the operation which you advise."

Well-prepared students may finish all three clinical tests in about six weeks as a minimal period, some allowance being necessary on account of the examinations of other students and intervening holiday or vacation periods. Most students devote more or less time to special preparation for the clinical tests, which may thus extend over several months. Some professors are dreaded, others are preferred. However, the student must take his

chances and has no choice in the selection of the jury before whom he must appear.

Very naturally, all examinations are given in French. On one occasion I remember, a foreign student, not very familiar with French, asked for an interpreter. His request not only embarrassed and prejudiced the jury, but elicited loud protests from the students themselves. "No special privilege!" is a student's slogan universally insisted upon in France, except in such wise as may permit one student to aid another. Dishonesty at examinations is severely penalized, but considered lightly by students of mediocre ability or industry. In accordance with the strong esprit de corps existing among students, able ones seldom refuse to assist their less fortunate comrades, although good students do not respect shirking, bluffing, incompetence or stupidity.

*Thesis:* This is invariably required of all candidates for French medical degrees. It is based upon work assigned or accepted by some professor selected by the student. This professor constitutes the thesis President, or President of the jury before whom the thesis will be sustained. The thesis may represent prolonged and valuable original work, or it may be prepared in a more or less rapid, summary and perfunctory fashion. However, it must be accepted by the President, who may, if he likes, assign a task requiring a year or more for its completion. Prolonged study is the rule with students who are interested in some special subject and who are in a position to do very thorough work, without being in any haste to begin practice. Such is the case with French internes, who have ample opportunity for extensive research during their usual five-year period, and who are not legally permitted to undertake private practice during their internship. Foreign candidates can usually prepare acceptable theses after some three months or more of work, especially if they are already in possession of data previously accumulated and acceptable to the thesis President.

Only after the three clinical examinations, already described, have been completed may the candidate proceed to the formalities attending the preparation of his thesis, although work on the latter may have been already done, wholly or in part. The professor selected having consented to act as President, and the thesis having been prepared in manuscript, the procedures indicated below may be complied with.

The manuscript and conclusions, signed by the thesis President, are filed with the secrétariat of the Faculty. The manuscript is then returned within forty-eight hours, bearing official permission to print. The candidate must bear the expense of printing and may select any printer preferred. The format of the thesis must be octavo. Theses for the *diplôme d'Etat* must be so designated on the cover. The *universitaire* theses must bear the expression, *Thèse universitaire, mention médecine*. Close attention should be paid to the latter points, otherwise embarrassment may occur. The printers are supposedly familiar with the procedure required for the printing of theses, yet they may make absurd and unpardonable errors. The candidate may consult, at any time, the official regulations, which are always left open to his use in the hall of the secrétariat. He should not fail to insist that they be followed precisely. In my own case, the printer, after assuring me that he would faithfully follow every detail, made the crass mistake of labeling my thesis *Universitaire*. Had I not been carefully following every step in the printing, copies wrongly labeled would have been filed with the Faculty librarian for general distribution and I might have had much difficulty in establishing my status as a candidate for official practice. Again, checking of the printing is especially necessary when the material contains technical formulae. During the printing, nothing should be left to chance and proofs should be carefully read and corrected.

When sure that the proof sheets are acceptable, and before the printing of the

desired number of theses, the candidate must file with the secrétariat a proof-sheet of the first page, which must bear the candidate's surname and given name, date and place of birth, the name and titles of the thesis President and a list of the professors who have presided over the student's hospital and other work. When these data have been filed, the thesis may at last be printed. At least one hundred and five copies are required, for this number must be deposited with the librarian of the Faculty for record and for distribution of a certain number of copies to different libraries or universities habitually receiving the copies from the university where the thesis is prepared. After filing the library copies, the candidate may pay the university fee required in connection with the thesis. Within two weeks after making this payment, the candidate will be assigned a date for defending his thesis, the last step preceding issuance of the coveted diploma.

Defense of the thesis is something of a ceremony. The candidate is interrogated by any or all of three jury members, of whom the thesis-President naturally occupies first place. The members wear their scholastic robes and caps. The occasion is open to the public, but there are usually no attendants except the candidates and one or two of their special friends. Students sometimes attend for the purpose of familiarizing themselves with the procedure. The ceremony is usually merely formal, for no difficulty should occur when the candidate has reached this point of his progress. However, I have heard sharp rebuke administered to a candidate who had not taken the pains to verify the formulas which he employed. The jury members promptly noticed the fact that the formulas, as expressed, were meaningless and roundly criticised the thesis for

these imperfections, assigning the lowest passing-mark to this work.

When the interrogation is completed, the jury members shake hands with the successful student, express a few congratulations and pass on to the next examinee. Not more than three or four are usually interrogated at the same séance. When the ceremony is concluded, the inevitable garçon informs the new doctors of the marks they have received and pockets the small tips bestowed by the survivors of this final ordeal. The diploma may now be claimed at the secrétariat of the Faculty. When the latter has been duly registered at the préfecture of police and at the police station, or commissariat, in the quarter where the new physician is to reside, the latter has become an actual member of the French corps médical and may begin his practice.

Many cherished details scarcely come within the scope of this paper, which must omit various charming or vexatious incidents which imparted unforgettable savor to the memories of the assault upon the walls of the Sorbonne and the siege of the inner and higher citadel constituted by the Ecole de Médecine. Another occasion must be reserved for amusing tales of student life, charming relations with members of the Faculty, battles with garçons and functionaries and thrills experienced by sharing in an immense and victorious strike of the students, organized to maintain medieval law and traditions of the University of Paris.

The entire experience was well worth while and leaves most delightful impressions and memories of the Paris Faculty of Medicine and the student-body of the University of Paris, seasoned exemplars and ardent initiates of traditions and principles which have marked, brilliantly and indelibly, the science and art of medicine.



## BOOK REVIEWS

**NERVOUS INDIGESTION.** By Walter C. Alvarez, M.D., N. Y., Paul B. Hoeber, Inc., 1930.

The debate is as old as the hills: Do book-reviewers read the books they review? I cannot answer for my neighbor but in this instance let me say I have read Alvarez' book from cover to cover. In fact, parts of it I have reread two or three times. In order that we start with the proper understanding necessary for faith and trust between writer and reader let me confess I am not a gastroenterologist. For this reason I think the opinions offered may be the more valuable. Over 90 per cent of the specialists in gastroenterology will read "Nervous Indigestion" for the simple reason they always read everything Alvarez writes. So this is not written for them. It is the man doing internal medicine, gynecology, general surgery, neurology and the other divisions of medicine I would reach.

To me this is a valuable book. It is valuable because Alvarez has chosen a subject which has been neglected. He has covered the field in admirable fashion. It is valuable because the author has not had an eye on a score of textbooks and written in the dry, didactic manner so common in most scientific authors. As far as style goes Alvarez has a style all his own. His writing flows; it is always entertaining while instructive. We read his book at two sittings.

The first chapter considers Ways in Which Emotion Can Affect the Digestive Tract. It opens with two queries: "What does a physician mean when he says that a patient has nervous indigestion? Just how does the tired brain produce distress in the abdomen?" We will quote a paragraph or two:

The most striking evidence of a psychic increase in tone activity was seen in a jolly bon-vivant whose anal sphincters had been destroyed by a series of operations for fistulas. As a result, many of the rush waves down the bowel, instead of stopping as they normally do at the ileocecal sphincter or somewhere in the colon, ran on and produced a bowel movement. The interesting point is that in this man the sight and smell and even the thought of food produced rushes.

Chapter II deals with Types of Indigestion. Alvarez says, "Nervous indigestion is a convenient term with which to designate all those gastrointestinal disturbances for which no organic cause can be found." The author goes deeply into this subject and then considers Gall Bladder Disease, Peptic Ulcer, Appendici-

tis [the subject of chronic appendicitis is worthy of more than passing note], Cancer of the Stomach, Cancer of the Colon, Diverticulitis of the Colon, and Intestinal Parasites. Under General Diseases we read, "There are a number of patients who think they have indigestion because they want to belch or because they feel as if gas were pressing up under the heart. Not infrequently these symptoms are due not to indigestion but to *high blood pressure* or to the distress of a *failing heart*. Obviously such patients cannot be helped by dieting but must be made to rest . . ." The pages on Fatigue Neurosis, Temperamental Indigestion, Anxiety Neurosis and Nervous Vomiting I especially recommend to you. Under enteroptosis we mentally applauded when we read, "I think I would as willingly ascribe symptoms to a large navel, to a hooked nose, or to flaring ears, as to a mobile cecum or to a redundant sigmoid flexure. The bowel is a muscular tube and I doubt very much if its position in the abdomen has much influence on the rate at which its contents are passed onward." . . . "This [mucous colitis] is another condition which accounts for much unnecessary opening of the abdomen." Alvarez reaches a high water-mark of writing when dealing with Constipation. He shows the dangers of the usual enemas. He says the patient should be taught to use nothing but a physiologic salt solution for washing out the lower bowel. Regarding diets he writes, "It is fashionable nowadays to treat constipation by the addition to the diet of bran, rough fruits, vegetables and other avowedly indigestible substances, but as might be expected, these materials often cause trouble. Those who have the digestion of an ostrich can stand filling the bowel with refuse . . . The use of hydrocarbon oil is also inadvisable in many cases . . ."

Hints in Regard to the Talking of a History comprises Chapter III. The following chapter is The Handling of the Nervous Patient. Alvarez says:

I have always felt sympathy for anyone with "nervous indigestion" . . . I feel sorry for those who while seeking help and guidance, fall into hands of men who wittingly or unwittingly rob them, maltreat them, and make them worse . . . Instead of being given sedatives and a better diet they are rushed to the hospital, there to part with an innocent appendix, harmless tonsils, or doubtful teeth . . . Sometimes it works but too often it doesn't.

Every physician may read with profit the chapters under Behavior of Nervous Patients. Throughout this remarkable book are hints on the many methods of handling all types of patients. Every young physician just opening an office will find much of intrinsic value, matter for reflection that might well be taken to heart and accepted rather than learning these bits of wisdom offered by the long, hard route of experience. For instance the line, "I have often thought that if a physician only knew just what to say and what not to say to each patient his success would be phenomenal" and the discussion following this observation is invaluable.

The next chapter deals with The Treatment of Nervous Indigestion. The subheadings of this chapter are: Symptoms are Real: What to Say: Methods of Handling Hysterical Patients: Avoiding Deception of the Patient: Psychotherapy: Rest: The Rest Cure: Sleep: Physiotherapy, Exercise and Massage: Eye Examination: The Importance of Teeth: Diet ("Nowadays one of the simplest ways of helping dyspeptic persons is to take away their bran mush and bran muffins.").

Chapter vi considers Some Practical Points About the Physiology and Innervation of the Digestive Tract. This may sound dull and make the reader think back to sleepy days in the laboratory or anatomic quiz-room. Far from it. How I wish Alvarez could have written my textbook on anatomy and taught me physiology!

The book ends with a chapter devoted to Suggestions For Further Reading.

The Index is complete.

Perhaps I have waxed too enthusiastic and written and quoted at too great lengths, but it is rare these days to enjoy reading a scientific book although that book may be a necessity on our library shelves; but when one finds a valuable book so well written and so full of wise philosophy and so human in its scope as this one by Alvarez one cannot help crying its virtues to the world. And this we hope we have done.

MEDICAL HISTORY OF MICHIGAN. Vol. 1. Compiled and Edited by a Committee, C. B. Burr, M.D., Chairman, and Published under the Auspices of the Michigan State Medical Society. Minneapolis, Bruce Pub. Co., 1930.

The increase of the interest in the medical history of this country, and the desire to render permanent the records of its beginnings before it is too late, are well shown in this large and handsome volume published under the auspices of the Medical Society of the State of Michigan. The work has been thoroughly and excellently carried out by the committee appointed for that purpose and it is evident that the knowledge and ability of its chairman, Dr. C. B. Burr, have had much to do with the success of the project. Although Michigan was a wild and sparsely settled country until well towards the end of the first half of the nineteenth century the communities which have since become its great cities were largely composed of men of ability and force of character and among them were a number of medical men who not only practiced their profession but also took an active part in public affairs. To these men we owe the foundation of medical schools like that of the University of Medicine and the high standing which the profession attained in Michigan at an early date and has successfully maintained to the present day.

Before the settlement of what is now the State of Michigan there is much of interest in the medical affairs of the pioneer French explorers and the Indians. In Chapters II and III of this book Dr. Burr reviews the available records. Considerable is known of Indian medicine partly from the pioneer settlers and partly from subsequent scientific investigations. It is curious to find that the Michigan Indians practiced trephining just as similar operations were performed by the aborigines of Peru, in the South Sea Islands, and elsewhere throughout the world. The French explorers were in many instances accompanied by surgeons and Dr. Burr gives interesting details of their experiences. One of them Liotot murdered the Sieur Moranget, La Salle's nephew, with an axe, in the course of La Salle's expedition to Louisiana in 1687. Later Liotot was himself murdered in a dispute with another member of the expedition. In the next chapter Dr. Burr tells of some physicians who practiced, chiefly as surgeons, in the Fort at Detroit. These were French until 1760 when the English took over the fort and settlement. When the United States occupied Detroit in 1796 the surgeons at the post were for many years the chief physicians in the town.

A United States army surgeon, William

Beaumont, won immortal fame at Mackinac in 1822, when he was acute enough to grasp the opportunity afforded by a gastric fistula following a gunshot wound in the side of a voyageur, and studied the physiology of the gastric digestion. There are many pages devoted to the pioneer physicians, their hardships and experiences. One of the most interesting chapters is that by Dr. J. H. Dempster on Medical Education. The first medical college in Michigan was the University of Michigan Medical School, founded in 1850, and now one of the great medical schools in the United States. Dr. Walter H. Sawyer presents a valuable contribution on Medical Journalism. The subject of Prevailing Diseases and Epidemics is well covered by Dr. C. B. Burr and the volume concludes with an excellent summary of Public Health Work in Michigan by Dr. Guy L. Kiefer.

The book is copiously illustrated with well chosen pictures. It is a pity that so large a volume, 829 pages, should not contain an index. We suppose that one will be provided in a future volume, but it would have been more convenient had it been placed in this one.

FRANCIS R. PACKARD.

**INJURIES TO JOINTS.** By Sir Robert Jones, Bart., K.B.E., C.B., CH.M. (Liverpool), F.R.C.S. (England, Ireland, and Edinburgh), F.A.C.S. (U. S. A.) Ed. 3, 196 pp., 29 illus., Oxford Univ. Press, 1930.

The third edition of Jones' "Injuries to Joints," begun as a war-time manual, fully maintains the standards set by the first two editions. It is to be regretted that the distinguished author does not enlarge the book so as to make it a complete text on the subject.

**PHYSICAL DIAGNOSIS.** By Richard C. Cabot, M.D. Ed. 10, Revised and enlarged. 552 pp., 6 plates, 279 figures. New York, Wm. Wood, 1930.

Any book that runs through ten editions in twenty-five years may be considered as having made its definite place in medical literature,

and this statement applies with unusual force to the book before us. In this edition, according to the author, "The more important new matter introduced relates to coronary disease, electrocardiography, cancer of the lung, cardiac asthma, toxic hepatitis, and encephalitis lethargica." Thoroughly up-to-date, Cabot's "Physical Diagnosis" may not only be freely recommended to students as a standard and thoroughly complete textbook on the subject but will be found valuable in the library of every physician and surgeon as a book for continual reference. Well written, well printed, concise and up-to-date, the book has made its place as one of the classics of American medical literature.

**GONOCOCCAL INFECTION IN THE MALE.** By A. L. Wolbarst, M.D. 297 pp., 133 illus. 7 col. plates, St. Louis, C. V. Mosby, 1930.

There have been several new books on gonorrhea in the last few years, all of them up-to-date and practical. This is the second edition of Dr. Wolbarst's book the first having been published in 1927. It is unfortunate that, as in the case of so many monographs, this book will be found to be too detailed for the general practitioner and not detailed enough for the specialist.

**MANUAL OF PHYSIOLOGY** for Students and Practitioners. By H. Willoughby Lyle, M.D., B.S. (Lond.), F.R.C.S., (Eng.) and David De Souza, M.D., D.Sc. (Lond.), F.R.C.P. (Lond.) 836 pp., 3 plates, 138 figs., London, Oxford Univ. Press, 1930.

For the third time since 1911 this book has been revised and brought up-to-date. In handy format, tersely written and well printed, this work makes a convenient and practical text and reference work on modern Physiology. By the use of a large type page, small type face and thin paper, the publishers have succeeded in putting a great amount of material into convenient compass and the authors have the happy faculty of eliminating the unessential, thereby making every word and page count.



# A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

EDWARD M. LIVINGSTON, M.D.

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# A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

## SECTION II. THE GASTROINTESTINAL TRACT

### B. ANATOMICAL AND PHYSIOLOGICAL DIVISIONS OF THE GASTROINTESTINAL TRACT (*Continued*)\*

"Nature," it has been asserted, "is interested in function rather than in appearances, in physiology rather than anatomy." And the value and effectiveness of surgical measures are to be judged largely upon the basis of functional end-results. It is insufficient that the surgeon think in terms of anatomy alone. In creating an intestinal anastomosis, for example, the facility and convenience with which two specific bowel segments may be approximated sometimes prove to be a consideration of less importance to the best interests of the patient, than the question as to whether it is this particular segmental union, or some other, which will most completely preserve or restore normal alimentation. In the realm of abdominal diagnosis, also, the interpretation of signs and symptoms rests to a considerable extent upon an adequate understanding of the subject of gastrointestinal physiology. Study of anatomical units of the alimentary canal with their purely arbitrary limits, (stomach, duodenum, ileum, jejunum, colon) reveals little to suggest the identity and location of functional divisions of the tract. And these, therefore, require separate review.

There are three major processes of alimentation, *viz.*, secretion, absorption, and excretion; the great functional divisions of gastrointestinal tract likewise are three in number. These are determined by the manner of distribution of alimentary blood

\* Previous installments of this book appeared as follows: Vol. viii: January issue, p. 193; February issue, p. 459; March issue, p. 693; April issue, p. 911; May issue, p. 1109; June issue, p. 1325. Vol. ix: July issue, p. 157; August issue, p. 365.

vessels, lymphatics and nerves. Physiological divisions, for this reason, are fundamental and basic in character. The names of these functional units are based upon the portions of the embryonic alimentary tube from which they arise (foregut, midgut, hindgut). The functional foregut of the adult (secretory division) terminates within the duodenum immediately below the site of entrance of the biliary and pancreatic ducts (ampulla of Vater). The termination of the functional midgut (absorptive division) lies within the left half of the transverse colon near the splenic or left colic flexure. Differences as to the location of anatomical and physiological divisions of the tract are, then, most clearly to be noted in the duodenum and transverse colon. The duodenum proximal to the entrance of the common bile duct is so similar in behavior to the pyloric end of the stomach that the two have been considered, both by surgeons and radiographers, as related.<sup>169</sup> The distal part of the duodenum, on the other hand, falls within a different physiological division. Points which illustrate the practical significance of functional variations within different parts of the duodenum will be dealt with later. Again, the transverse colon, extending between the right and left colic flexures displays, at its extremities, physiological differences which are so profound that it cannot be considered as a single functional unit.<sup>170</sup>

Functional vs.  
Anatomical  
Divisions

Visualization of these functional divisions is aided by reference to that stage of development in which the archenteron is still open in its mid-third into the yolk sac (Fig. 141.) The foregut is that portion of the canal situated cephalad to this yolk sac opening (parts cephalad to mid-duodenum); and the hindgut is the portion caudad to the yolk sac opening (all parts distal to and including the left colic flexure).

Embryological  
Basis for Divisions

The three functional divisions, it may be observed, receive their blood supply from separate sources. The foregut derivatives are nourished through the celiac axis; midgut derivatives are supplied by the superior mesenteric artery, and structures derived from the hindgut are furnished arterial

Vascular and  
Nervous Supplies

blood by way of the inferior mesenteric artery. The sympathetic nervous system sends fibers to all parts of the gastrointestinal tract, but the supply from the autonomic

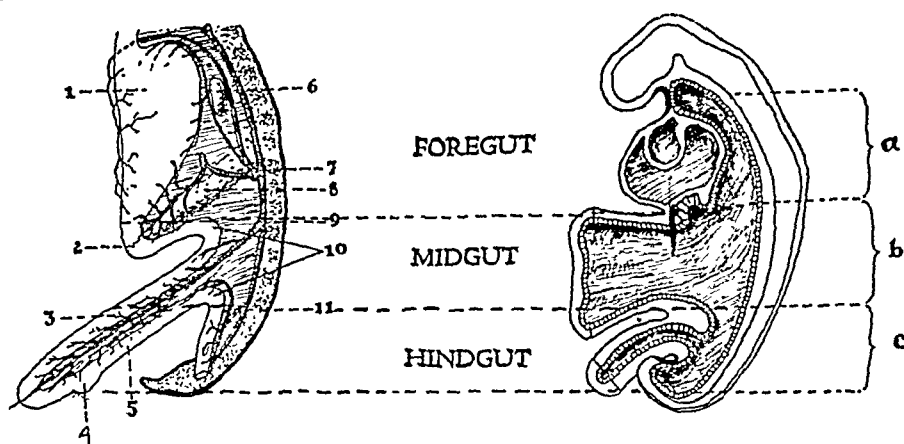


FIG. 141. The functional divisions of the gastrointestinal tract.

a. Foregut. b. Midgut. c. Hindgut.

1. Stomach. 2. Duodenum. 3. Descending limb of intestinal loop. 4. Cecal bud. 5. Ascending limb of loop. 6. Spleen. 7. Pancreas. 8. Superior mesenteric artery. 9. Duodeno-colic isthmus or base of loop. 10. Duodeno-colic isthmus or base of loop. 11. Inferior mesenteric artery.

system differs with the different functional units. The foregut and in part the midgut receive fibers from the bulbar autonomic (vagi) while the hindgut receives fibers from the sacral autonomic trunks (nerves erigentes or pelvic vagi).

If the functional divisions are less frequently referred to in surgical literature or seem less perfectly understood, it is probably because as has often been reiterated "operators are on the whole far better anatomists than physiologists." Much of surgical literature falls within the realm of applied anatomy. And it is, perhaps, a fair generalization that anatomy, the older subject, is the more fully presented as to its surgical aspects. Anatomical literature, also, seems to possess a certain precision which appears yet wanting, at times, within the sphere of physiology. Compare for example a description of a vagus nerve with a discussion of vagus functions. But to the truism that the surgeon must "think anatomically" might well be added the admonition that he "act physiologically."

A. J. S., n. s. Vol. IX, No. 3, p. 584

And time spent in study of gastrointestinal physiology is amply repaid both in terms of improved surgical end-results and of increased clinical acumen.

The present review of gastrointestinal physiology will adhere to the previously adopted method of giving an admixture of basic with practical topics. The aim is a correlation of physiological facts with everyday surgical matters. The abrupt transition from one practical topic to another, an inherent shortcoming of this approach to the subject, is compensated for, to a degree, by the headings given individual paragraphs.

As might be anticipated, because of the overlapping of nerve fibers and the anastomosis of blood vessels at divisional boundaries, functional activities extend somewhat beyond general territorial limits. Thus within the stomach (secretory division) there is chiefly an outpouring from the mucous membrane of gastric juice with its hydrochloric acid, pepsin, rennin, lipase and mucin; but to a limited degree absorption also takes place from this viscus. Gastric absorption, however, is so slight that if foods reach the stomach alone, starvation soon results. And the surgeon knows that when he deals with an obstruction to the pylorus which is becoming complete, it is essential that some method such as a gastric resection, gastroenterostomy or jejunostomy, be employed to allow nourishment to reach the functional midgut. The mucosa of the stomach absorbs practically nothing but limited amounts of alcohol, simple sugars and certain of the mineral salts.<sup>171</sup> Even water, which normally passes at once to the duodenum along the lesser curvature (magenstrasse or canalis gastricus) is not absorbed by the gastric mucosa.<sup>172</sup>

#### Gastric Absorption

The distal colon or expulsive division of the bowel (descending, iliac, pelvic colon) similarly, has little absorptive power. This terminal third of the gastrointestinal tract is to be considered as chiefly a storehouse to accommodate feces until a convenient time for their evacuation.<sup>173</sup> Unaltered proteins are not taken up by the colic mucosa and fats remain unabsorbed.

#### Absorption in the Distal Colon

The administration of so-called "nutrient enemata" of eggs, beef juice, cream, etc., seem, accordingly, irrational. Of nutritive substances monosaccharides alone are absorbed. And it is even stated that about 80 per cent glucose remains within the colic lumen.<sup>174</sup> Water and sodium chloride may be introduced by rectum (Murphy drip; Harris drip; rectal infusion; proctoclysis); but in calculating the patient's nutritive and fluid balance the surgeon must take into account the limitations and uncertainties of colic absorption. Sugar solutions administered in high concentrations (i.e. above from 3 to 5 per cent) may so irritate the rectum that the patient cannot retain the substance. Thus the possibilities of rectal feeding are slight; obviously the function of the terminal colon is almost exclusively excretory or expulsive. And secretory activity within this portion of the bowel is limited to the discharge of mucus, that natural lubricant essential to normal defecation.<sup>173</sup>

Introduction of  
Fluids with Bowel  
Stasis

With adynamic ileus (bowel paresis or paralysis) the surgeon finds himself unable to administer desired amounts of fluids or nourishment since the stomach and colon (secretory and expulsive divisions) are unable to provide the requisite absorption. Hypodermoclysis or direct infusion of saline or glucose must then be resorted to. Postoperative intestinal stasis may be anticipated by having the patient swallow a duodenal tube before operation. Then fluids may be placed at will directly into the absorptive part of the alimentary canal. When bowel stasis is marked, however, and the absorptive powers of the mucosa are severely impaired (edema, vascular occlusions, lowered portal circulatory pressure) water and nourishment must be administered by other routes. It is of historical interest to note that prior to the period of asepsis the surgeon was incapable of safely administering liquids by any avenue other than through the alimentary canal (mouth or rectum); and not the least benefit or boon of asepsis is the ability to secure absolute sterility of fluids to be placed beneath the skin, into the peritoneal cavity, or into the circulation for the combat of shock and dehydration.

There has been provided to a remarkable degree a compensatory mechanism whereby in certain abnormal states one functional bowel division may assume to a far greater extent

Physiological  
Compensatory  
Mechanisms

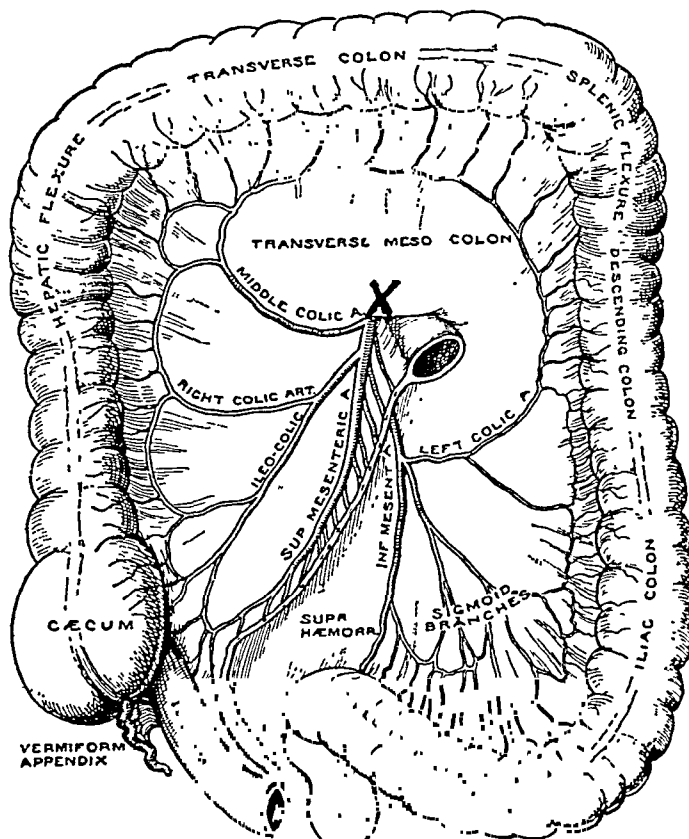


FIG. 142. Embolic plugging of the superior mesenteric artery.

A. Demonstrates how complete stoppage of the superior mesenteric artery (point x) causes gangrene of intestine from the proximal jejunum to the transverse colon. Loops of small intestine have been removed to show the colic circulation but their arterial supply may be seen within the root of the mesentery. (From Taylor's Operative Surgery.)

than usual the functions of another. Cases are reported in which almost all of small bowel (absorptive area) has been resected yet the patients survive over periods of months or years.<sup>175</sup> Such extensive resections have been made as a desperate necessity after embolic plugging of the superior mesenteric artery with resulting jejunoileocolic gangrene (Fig. 142). Beginning within healthy bowel distal to the area of gangrene

the surgeon has incised the mesentery along most of its 6 in. base, thereby freeing loop after loop of small intestine until healthy gut proximal to that found black was encountered.

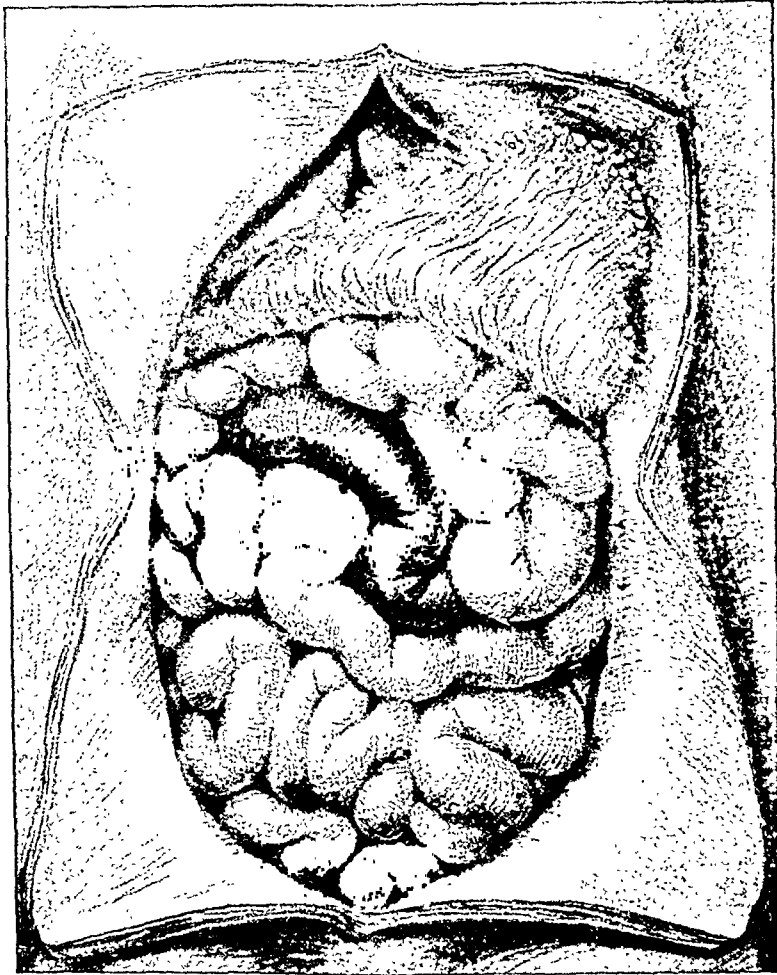


FIG. 142. Embolic plugging of the superior mesenteric artery.

B. Shows gangrene of a single loop of intestine from embolic plugging of a small branch of the superior mesenteric artery. (From Eisendrath's *Abdominal Diagnosis*. W. B. Saunders & Co.)

The subsequent anastomosis of the jejunal stump to the ascending or transverse colon has left the patient with only those portions of the gastrointestinal canal supplied by the celiac axis and the inferior mesenteric artery (i.e. the func-

tional secretory and expulsive divisions). The remarkable recoveries which have followed such removal of over 15 ft. of intestine well illustrate a great compensatory or adaptive mechanism. Notwithstanding, however, both slight natural overlapping of functions and such compensatory activities as observed in abnormal states the three main functional processes of alimentation are carried on to a major degree within the three great functional divisions of the gastrointestinal canal.

The practical significance of physiological divisions will be further illustrated by certain points relative to intestinal fistulae and stomata.

From a high jejunostomy there is a copious and almost continuous outpouring of liquid which is highly irritating to tissues of the body wall. This substance (chyme) reaches the surface before traversing the absorptive area of the bowel and a marked loss from the system of nutriment consequently results. Clinically the distressing signs and symptoms of dehydration and starvation follow. A high fistula shows little tendency to spontaneous closure and unless it be dealt with by secondary operation will continue to discharge, if the patient survives, for from six to nine months, or perhaps permanently.<sup>176</sup> Thus although a high jejunostomy for intestinal obstruction may relieve bowel distention and rid the patient of material of marked toxicity, proving at times a life-saving measure, the advantages may be largely abnegated by disagreeable and dangerous late effects unless the jejunostomy is promptly closed by the surgeon after its purpose has been fulfilled. Low bowel fistulae produce less dehydration and starvation, their discharges are intermittent and prove less irritating, and they exhibit a definite tendency to close spontaneously.

Surface excoriations and digestive changes in the belly walls about jejunal stomata have been dealt with satisfactorily through furnishing the pancreatic and intestinal enzymes, (trypsin, erepsin, amylopsin, maltose, lactose, lipase) suf-

High vs. Low Jeju-  
nal Fistulae

Feeding Intestinal  
Enzymes



ficient food upon which to act. This "feeding of the ferments" in order to spare the patient's own tissues has been accomplished both from within and from without. A diet rich in eggs, for example, has effectively stopped the proteolytic changes in living structures.<sup>177</sup> Again, the desired effect has been produced by saturating the surgical dressings with kaolin,<sup>178, 179</sup> or by beef juice; also by applying steak to the surface. Weak hydrochloric acid added to the protein used in the dressings serves to neutralize excessive alkalinity of the succus entericus. So characteristic of high intestinal fistulae is the presence of deep-seated adjacent excoriation and tissue digestion that the surgeon can usually tell by inspecting the wound, when a fistula which he is examining for the first time is of jejunum and when of colon or some low segment of bowel. Colic fistulae are as a rule free from severe surrounding irritation.

#### Diet with Artificial Ani and Fistulae

For a patient having an artificial anus or enteral fistula diet plays a rôle of considerable importance in determining postoperative comfort.<sup>174</sup> A patient who is observant, after study of his stoma, can soon know with fair accuracy what foods he may safely ingest. In general the diet should contain little that is bulky or leaves a quantity of residue. Raw foods tend to be acted upon only low in the gastrointestinal tract for cellulose coverings are not dissolved by the enzymes but rather are broken up by the action of bacteria and by putrefactive changes in the colon. Naturally such foods are disadvantageous with fistulae. Cathartics and cathartic foods (figs, prunes, baked apples, bran, cereals) tend to cause discomfort with high fistulae. Simple sugars, eggs, meat juices, milk and milk products are among the most acceptable foods in most cases. With high jejunal stomata, as stated, a diet rich in proteins diminishes the irritating qualities of the fistulous discharges.

#### Mucous Fistulae

Feces is not as the layman usually believes chiefly composed of undigested residue from ingested foods. The greatest bulk is formed of waste products of the intestinal canal and its deriv-

atives (secretions and excretions) plus bacteria; food remains constitute but a small fraction of this alvine discharge.<sup>180</sup> The postoperative patient, though receiving no food or having an exceedingly limited intake still forms feces which needs elimination and this substance does not vary greatly from that produced during health. Any moderate increase during health, as is shown by stool examinations, is due less to undigested food materials than to the degree of activity of liver, pancreas and glands along the intestinal canal which activity tends to be greater in the normal healthy individual than in one confined to bed. These facts relative to feces and the output of the alimentary mucosa make it clear that a loop of bowel which is closed at both ends, hence isolated from the alimentary current, even though rendered functionally inactive, cannot safely be returned to the abdomen. If for any reason such isolated intestine cannot be resected it must be opened and a permanent communication made with the surface.<sup>181</sup> Such a stoma is referred to as a mucous fistula. As functional demands are withdrawn from this isolated bowel its mucosa gradually degenerates and atrophies and the discharge from the mucous surface necessarily diminishes; yet an occlusion of the external opening ensures an ever increasing distention of the loop which invites disaster. A completely isolated loop, open at each extremity with a mucous stoma, is referred to as a "Thiry-Vella fistula."<sup>182</sup> (Fig. 143.)

It is the custom of some operators when attempting an appendectomy in a difficult case to work from the base of the appendix toward its tip, rather than the reverse. In the most exceptional of instances after the appendix has been severed and the cecal stump inverted, it is found almost impossible or quite unsafe to remove the deeply situated and adherent tip of the appendix. Here the possible expedient might well be employed of attaching the base of the severed appendix to the skin wound as a short mucous fistula, rather than to leave the diseased organ entirely within the peritoneal cavity.



FIG. 143. Operation for the elimination of the ascending, transverse and descending colon; intestinal exclusion. The ileum has been severed 10 cm. from the cecum and the cecal end passed through a McBurney incision, making a permanent colostomy at this point. The sigmoid has also been severed and the end of the descending colon passed through a similar McBurney incision on the left side. An end-to-end anastomosis was then made between the proximal end of the ileum and distal end of the sigmoid, and a rectal drainage tube passed up into the ileum. The colon can now be flushed out through its two colostomy openings. (From Ochsner and Percy's *A Manual of Surgery*.)

In creating a temporary stoma in the treatment of paralytic ileus caused by acute peritonitis one does not hesitate, with the patient in a critical condition, to utilize any presenting loop of bowel in preference to making an extensive search for a more desirable segment. This permission to "use any loop" should not, however, be extended to situations where permanent artificial ani are being created. Here, other things being equal, that portion of gut should be utilized which will leave the patient with as much normally functioning bowel as is feasible. To employ small bowel in making a permanent anus throws the entire colon permanently out of function and results in the constant drizzling of nutritive chyme as described under the heading of jejunal fistulae. When the descending or sigmoid colon is selected for a permanent anus the outflow of feces is intermittent and from the excreta all food value has been removed; hence no marked starvation or dehydration ensues. For a permanent artificial anus the terminal functional third of bowel represents the site of election.<sup>183</sup> To use a midgut derivative places a distinct drain upon the patient's nutritional balance and to use a foregut derivative for this purpose makes quite certain a relatively short life expectancy. It is true that the variety of conditions which call for artificial ani make it necessary to individualize and to arrive at the decision as to the exact site for the stoma only after taking into consideration all of the factors involved; the pathological necessities of the case, matters of anatomical convenience, of the appearance and comfort of the patient, but above all of the functional end-result.

Generalizations similar to the foregoing apply with equal aptitude to intestinal short circuits or exclusions. By an "exclusion" of the bowel is meant the surgical procedure for rendering any portion of the intestinal canal functionally inactive; the segment thus eliminated by the short circuit is said to be "excluded." Such an operation may be necessitated by the presence of a growth which cannot be removed, in which case the portion associated with the tumor is excluded and the

A Temporary vs. a  
Permanent Artificial  
Anus

Intestinal  
Exclusion or  
Segregation

intestinal current thus diverted from the diseased area. A portion of bowel containing a fistula may be excluded (for example a tuberculous loop containing a spontaneously created

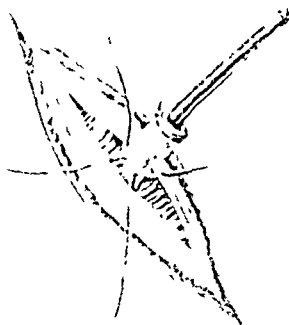


FIG. 144. Appendicostomy. The incision in the skin is made long to show the details of the operation. It need not be longer than 1 to 1½ inches. (From Moynihan's *Abdominal Operations*. W. B. Saunders & Co.)

sinus) in order that the stoma may close and the diseased bowel heal. The basic principle is to exclude as little of the alimentary canal as is consistent with the pathological condition being dealt with, and to preserve as much as possible of each of the functional thirds of the tract. Thus to short circuit about an irremovable neoplasm at the splenic flexure (left colic flexure) a colo-colic anastomosis (joining transverse colon to sigmoid or pelvic colon) is preferable from the standpoint of functional considerations to an ileosigmoidostomy.<sup>184</sup>

Preliminary  
Stomata

A preliminary stoma or fistula is sometimes required as part of a two-stage or multiple-stage operation. In the presence

of an obstruction low in the colon a preliminary colostomy, cecostomy or ileostomy allows the patient to be treated until the systemic effects of the bowel stasis present have been relieved. Colic resections performed in the face of acute obstruction are almost always fatal, hence "with acute colic obstruction temporary stoma production becomes an imperative necessity." To create a cecostomy or appendicostomy is a simple procedure which can be performed under local anesthesia (Fig. 144). At the time of colic resection (second stage) such a fistula or enterostomy above (cephalad to the site of anastomosis) relieves postoperative tension at the anastomotic suture line. Of all the precautions necessary to success with resections of the colon (prevention of contamination at time of operation; provision by suitable drains for possible leakage; peritonealization at suture line, etc.) none is of greater importance than the prevention of tension after the anastomosis by means of such an associated fistula higher in the gastrointestinal tract.

Spontaneous closure of temporary fistulae is prevented by bowel obstructions distal to the stoma and by eversion of the mucous membrane. (Fig. 145 c and F.) Thus to ensure prompt closure of a fistula designed for but temporary aid in the functioning of the bowel it is necessary to see that stenosis beyond the stoma has been relieved. But in addition early closure may be aided through attaching only a small part of the anti-mesenteric border of bowel to the body surface, or through using a small caliber tube buried within the bowel wall after the Witzel method and passing this tube on its way to the surface through a hole created for the purpose within the great omentum (Fig. 146). The latter method prevents pouting of mucous membrane and it is quite certain that if there is no bowel obstruction remaining beyond the fistula it will close promptly upon the withdrawal of the tube, the omentum acting as a plug.

Additional illustrations of the practical significance of bowel divisions, both anatomical and physiological, will be

Early Closure of  
Temporary  
Fistulae

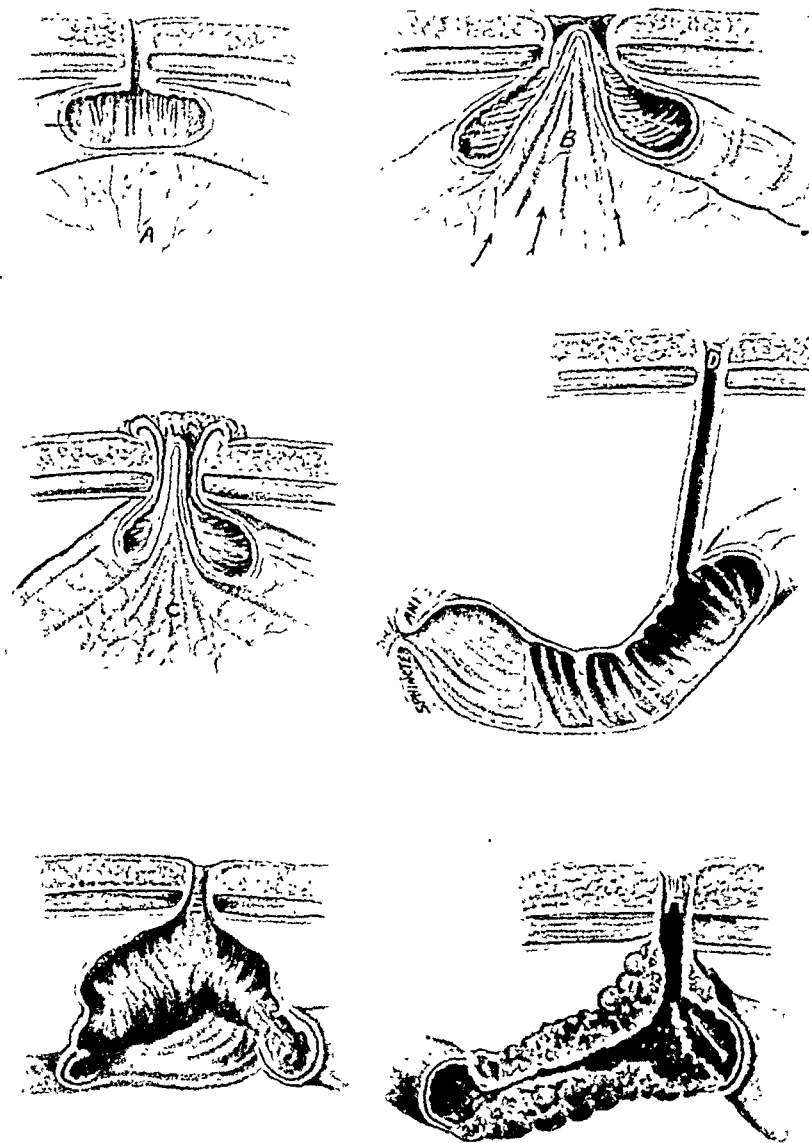


FIG. 145. Types of fecal fistulae.

A. Simplest form. B. Spur formation or reducible hernia type. C. Artificial anus or irreducible hernia. D. Fistula leading to intestine remote from abdominal wall. E. Fistula leading to large cavity resulting from gangrene due to mesenteric embolism. F. Fistula leading to intestine above cancer. (Coffey.)

furnished by a brief review, from a clinical standpoint of certain important intestinal diseases.

There are but three common surgical diseases of bowel

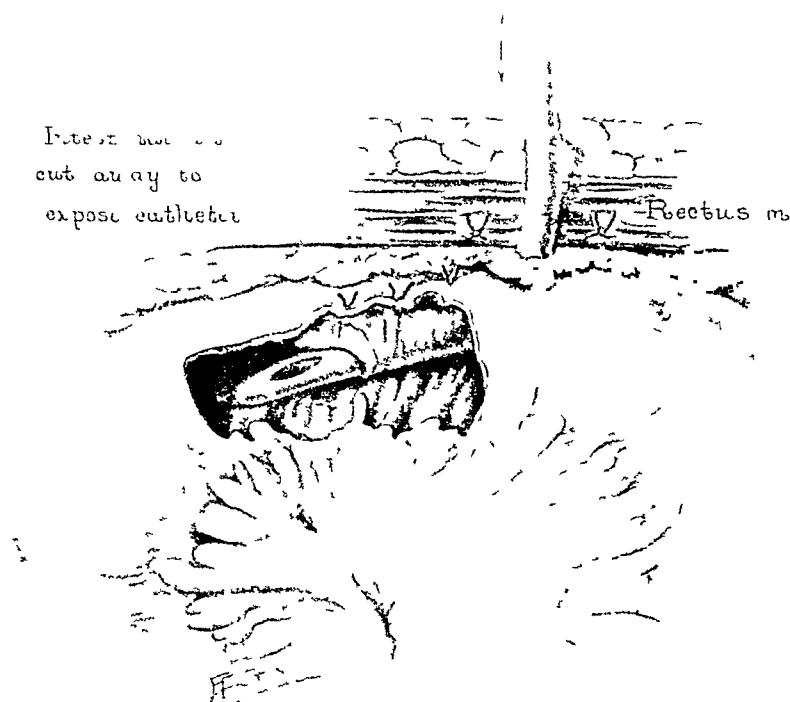


FIG. 146. Tube enfolded in the wall of the bowel, passing through the omentum and the abdominal wall (After W. J. Mayo)

between duodenum and rectum. These are (1) appendicitis (2) acute intestinal obstruction and (3) neoplasms. Hospital records show that over 90 per cent of signs and symptoms with proved surgical disorders of this portion of bowel (from duodenum to rectum) arise from one of these three conditions.<sup>185</sup> Acute intestinal obstruction, affecting as it does all parts of the bowel, serves quite ideally to illustrate differences in function at various levels within the alimentary canal.

Intestinal obstruction is classified in many ways; but to the clinician the most important is according to the site at

Common Surgical  
Diseases of  
Intestine



### Clinical Varieties of Intestinal Blockage

which the intestine is blocked. Complete bowel stoppage, if unrelieved, terminates fatally but the fatal outcome is much more prompt when the point of obstruction is high in the canal. Not only does the site determine in large measure the potentialities of the condition but also the character of the picture observed at bedside examination and the rate of progress of the disease (fulminating course; delayed course). Accordingly intestinal obstruction of the mechanical type is classified clinically as (a) high obstruction and (b) low obstruction. The site for incision, the prognosis to be given, and the type of after-treatment to be employed depend upon ascertaining, if possible, the site at which obstruction has occurred.

### Causes of Death with Intestinal Obstruction

A fatal outcome with intestinal obstruction is often due to a terminal and associated peritonitis; but the more immediate causes of death are (1) loss of fluid from the body (2) disturbance of the acid-base equilibrium, due to rapid elimination of substances contained within the lost fluid, and (3) a toxemia, apparently caused by the absorption of highly toxic material known to exist within the lumen of the obstructed bowel.<sup>186</sup> The higher the site of obstruction, the more prominent are the latter factors and the more rapid and certain the fatal issue. The reasons for this fact involve basic considerations regarding physiological chemistry and functional variations throughout the alimentary tract. These will be taken up for review after other clinical and diagnostic points have been dealt with. And statements as to specific mortality rates, both with high and low types of obstructions, with and without operations, will be reserved for subsequent paragraphs which have to do with treatment and aftercare of this important surgical disorder.

### Types of Vomiting

It is by persistent vomiting, a cardinal sign of intestinal obstruction, that such large quantities of water and essential substances leave the body, causing the dehydration and in part the disturbance of the acid-base equilibrium. With duodenal and upper jejunal obstructions vomiting tends to begin early, to be almost continuous, and to be copious in amount; the patient may die within a relatively few hours, the con-

dition running a fulminating course with a rapid loss first of gastric contents, then of mucus and bile, and finally of a brownish fluid having a fecal odor. The vomitus may seem

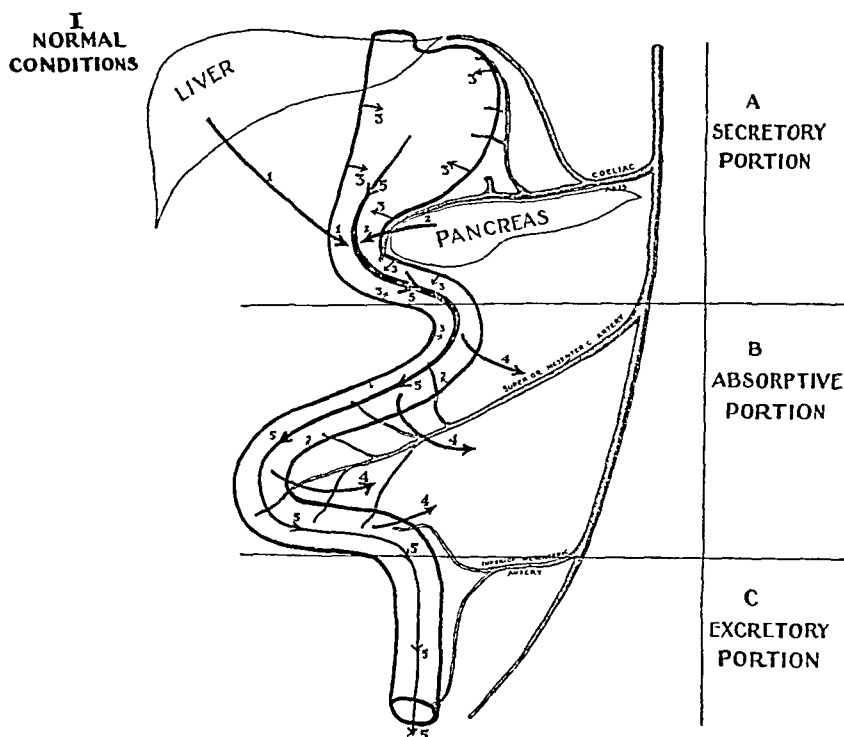


FIG. 147A.

1. The inflow (1, 2, 3) is balanced by intestinal absorption (4) and the small outflow (5). 1. Biliary inflow. 2. Pancreatic inflow. 3. Gastrointestinal outflow. 4. Intestinal outflow. 5. Anal outflow.

to well-up from below repeatedly and continuously in mouthful amounts as though simply representing an overflow, unassociated with nausea or effort on the part of the patient (regurgitant vomiting). This may occur when no food is being ingested or water taken by mouth. An explanation of this clinical observation is the following: with high obstructions the bowel above the blockage is being rapidly filled with fluids which enter the lumen by way of the mucosa, since secretion is the function of foregut derivatives; (it is stated that the amount of liquid secreted into the intestinal lumen within a period of twenty-four hours more than equals the total bulk of

the blood and lymph of the body);<sup>187</sup> the fluid cannot pass downward to be absorbed as it would under normal conditions and the only outlet for the overloaded bowel is into the stomach

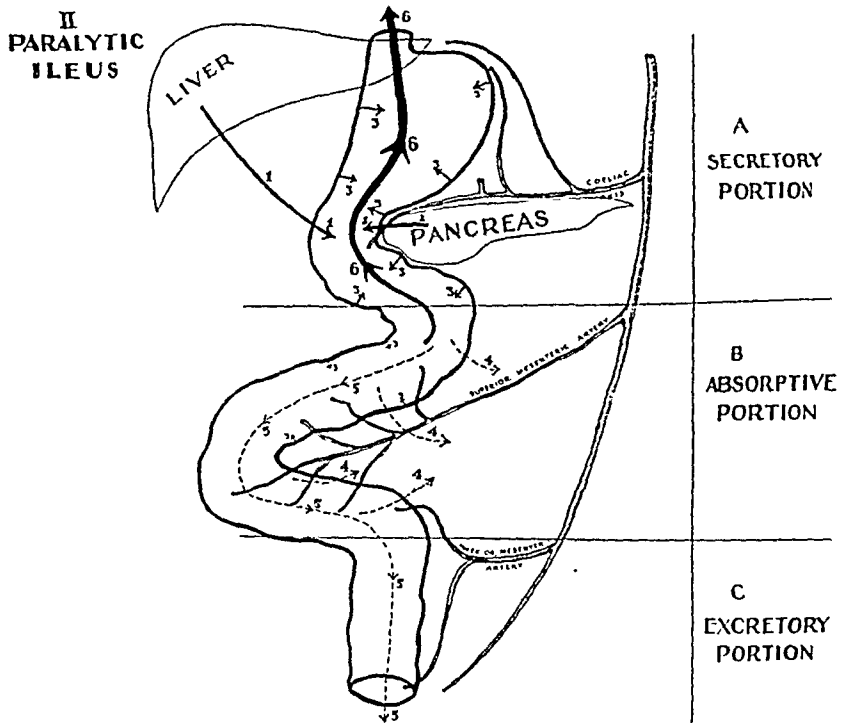


FIG. 147B.

II. Paralysis of the intestinal musculature is followed by marked abdominal distention followed by overflow or regurgitant vomiting (6). Intestinal absorption (4) is greatly diminished and nothing is passed by anus (5). Compare type of distention with that of high mechanical obstruction. 1. Biliary inflow. 2. Pancreatic inflow. 3. Gastro-intestinal inflow. 4. Intestinal absorption. 5. Anal discharge. 6. Buccal outflow.

and out through the mouth (Fig. 147, II). Upon the other hand, with acute obstructions low in the canal (colon) vomiting tends to be delayed, scanty or absent. There may be a single seizure of vomiting such as occurs with any severe intra-abdominal insult (initial vomiting), but the obstruction may be complete over a period of many hours or even days without a repetition of the occurrence or the onset of repeated vomiting. Even the preliminary or initial seizure may be absent.

Accumulated material passing toward the stomach and mouth, with low obstructions, must pass through the absorptive area of the bowel, where the amount becomes so greatly reduced

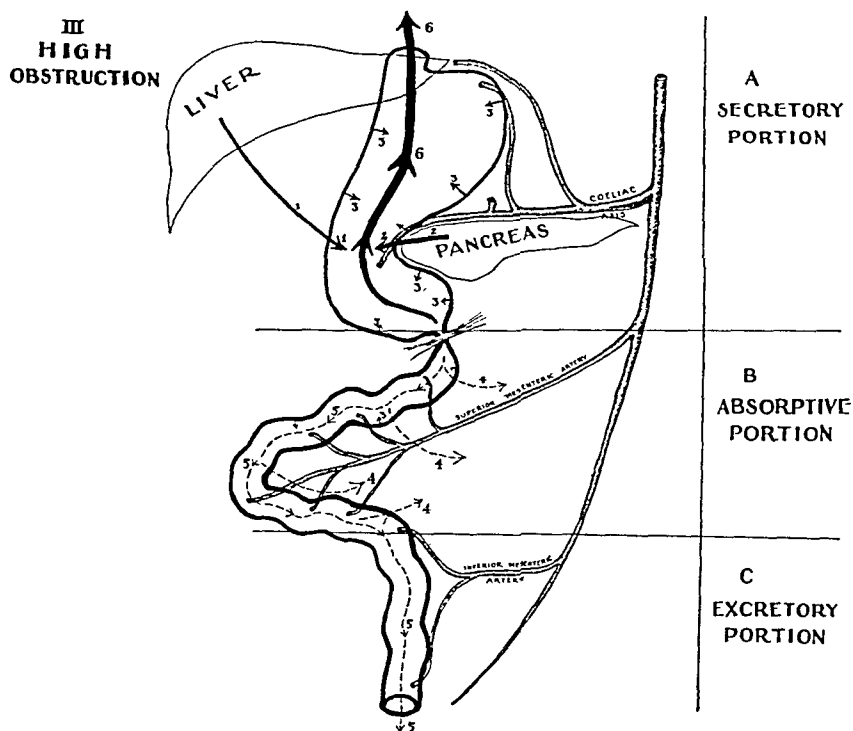


FIG. 147C.

III. Due to blockage proximal to the absorptive area (4) the only outlet for the overloaded stomach and duodenum is by way of the mouth (6).

that the tendency to vomiting is diminished or eliminated (Fig. 147, III).

Fecal vomiting, as the term implies, means the expulsion of vomits which contains particles of feculent material. Obviously this could be present only with obstruction very low in the intestinal canal, for it is only here that feces is found. Yet clinically vomitus containing true feces is seldom, if ever, observed. And so-called "fecal vomiting" often is merely the condition in which the expelled material is dark in color and has the strong odor typical of colon bacillus infection. Vomiting of the latter type need not imply that the point of obstruction

Fecal Vomiting

is low in the canal, for with stasis colon bacilli will invade portions of the bowel normally free from gross contamination with putrefactive organisms, and in obstructed segments

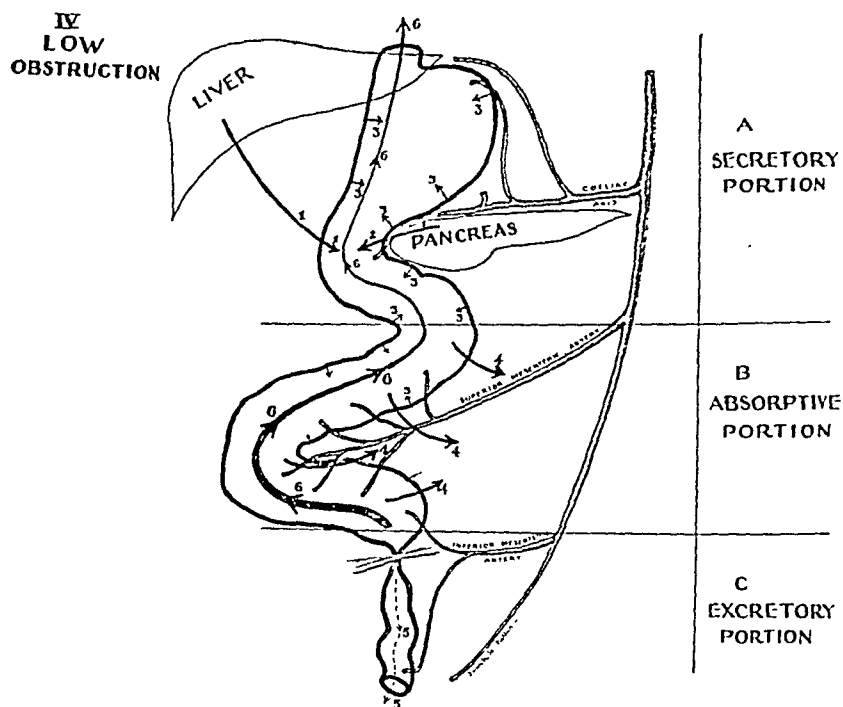


FIG. 147D.

iv. Outlet by way of the anus (5) is blocked but as the intestinal content is forced upward toward the mouth (6) much is absorbed (4), delaying and diminishing the act of vomiting. 1. Biliary inflow. 2. Pancreatic inflow. 3. Gastrointestinal inflow. 4. Absorptive outflow. 5. Anal outflow. 6. Buccal outflow.

bacteria multiply with unusual rapidity causing the changes in the color and odor of the intestinal contents<sup>188</sup> (see work of Cushing on intestinal flora).<sup>189</sup> After an abdominal operation, similarly, where the bowel wall has been found severely damaged, it is not uncommon to observe within from one to three days a wound discharge which is dark and odorous. The tendency is to judge that a fecal fistula has formed, yet the definite opinion that this complication has arisen may well be withheld until true fecal discharges or copious amounts of gas have been noted, for the condition may represent a colon

bacillus peritonitis with resultant discoloration and odor to the discharge, and the leakage may so abruptly terminate as to make it quite certain that no fistula was present.

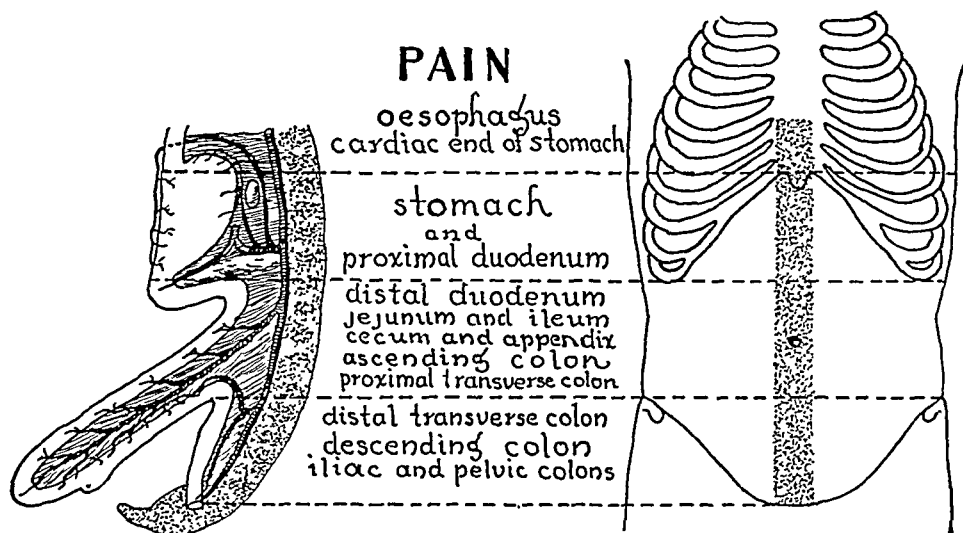


FIG. 148. Study of reference of gastrointestinal tract pains to three equidistant zones in midline of anterior abdominal wall.

The site of pain experienced with acute intestinal obstructions serves still further to emphasize the importance of a division of the gastrointestinal tract into thirds. It has been noted in foregoing pages that there are three equidistant zones along the midline of the anterior abdominal wall to which pains arising from affections of the stomach and intestines may be referred (Fig. 148). These surface areas, it was observed, represent the sites for pain reference for the functional thirds of the tract. In the presence of acute obstructions, accordingly, the clinician often is furnished with a physiological guide (pain-reference) as to the location within the canal of the obstructive process. To illustrate: Given a patient complaining of colicky pain localized a short distance above the umbilicus (and associated with other signs and symptoms typical of obstruction) the suggestion is that the jejunum is the bowel segment involved (physiological deduction); and if this patient has also a visible and tympanitic mass within the left hypochondrium, the

Midline Pains with  
Obstructive  
Lesions

evidence supports the supposition that there may be present a herniation into the retroperitoneal tissues through the fossa of Treitz (anatomical deduction).<sup>190</sup> Again, given a patient who for years has been a sufferer from chronic duodenal ulcer but now complains of pain within the hypogastrium, even the past history of a proved ulcer or the persistence of a duodenal cap deformity as demonstrated by roentgenograms does not remove the suspicion that the present complaint arises from some lesion within the colon rather than one within the duodenum,<sup>190</sup> and digital, or instrumental examinations of the rectum and radiographic examinations of the colon are definitely indicated. In ways suggested by such cases anatomical and physiological leads are to be followed and correlated and weighed with other types of diagnostic evidence in attempting to ascertain the presence and nature of gastrointestinal tract affections.

Two Distinct  
Types of  
Abdominal Pain

There are two distinct types of severe pain which occur with surgical disorders within the abdomen. With acute intestinal obstructions either or both may be observed. The first type of pain is the typical colic. This comes and goes characteristically and is due, in all probability, to intermittent peristaltic efforts upon the part of the intestine to overcome the resistance at the point of blockage of the bowel (smooth muscle spasm; see biliary colic, renal colic). This pain is usually referred to the midline. By derivation the term colic implies that the seat of the pain is in the colon but this original meaning has been superseded by a broader application of the word. Colicky pains (visceral disturbances) are often associated with sensory, motor and trophic changes, segmental in their distribution, within tissues of the body walls (see visceral neurology). The second type of pain seems deep seated and is more constant or steady in character. It may be referred to any part of the abdomen. This pain is often associated with rebound tenderness and supposedly is due to inflammatory changes in the peritoneum. By rebound tenderness is signified the sudden discomfort experienced by the patient as the examiner's fingers, which

have been pressed deeply and steadily inward toward the peritoneal cavity, are quickly withdrawn. Motor and sensory changes in the body walls, when these are present with the second type of pain, are not segmental or metameric as to distribution, a fact of obvious importance in abdominal differential diagnosis. With acute intestinal obstruction the pain picture varies with many factors, among them, the underlying or primary causative lesion, the type of patient, the condition of the patient at the time of examination (toxemia exhaustion, the recent use of opiates, etc.); this pain picture may rapidly change or shift with progressions or regressions of the pathological process within the abdomen (gangrene, perforation, spreading peritonitis). Of the two types of pain either may be present alone or both may be present simultaneously, sometimes one and sometimes the other predominating. But in general, the typical pain of acute mechanical intestinal obstruction is colicky in character; when a secondary steady pain becomes superimposed it usually implies the onset of a complicating peritonitis due to bowel leakage consequent upon gangrenous or other vascular changes in the gut wall at the site of obstruction or within the obstructed loop.

Moving Clinical  
Pictures

Ingested foods are carried along the alimentary canal by the action of smooth muscles within the walls of the esophagus, stomach, and intestines; digestive juices (ferments, acids, alkalies) are added by the alimentary glands; after selective absorption of nutritive elements into vascular and lymphatic channels has occurred, needless food residues and end-products of the digestive process are, at a convenient time, expelled from the body. This threefold function of the gastrointestinal tract (secretion, absorption, expulsion) abruptly terminates when for any reason (see classification) the bowel becomes acutely obstructed. With complete stoppage neither flatus nor motion is passed spontaneously through the rectum (absolute constipation). Even enemata and irrigations can bring down nothing from above the point of obstruction and after the distal

Four Chief Sym-  
ptoms of Acute  
Obstruction



bowel has been washed out, fluids will return clear. The one exception to the rule of absolute constipation is that of intussusception in which bloody and mucous diarrheal discharges arising from invaginated bowel may be passed. As the bowel lumen fills with fluids and gases above the point of obstruction (recall the amount of secretion entering the bowel lumen within twenty-four hours) this upper portion of tract (cephalad) undergoes rapid and steadily increasing distention. With high obstructions, since there is little or no absorptive activity within the cephalad loops, the only outlet is by way of the mouth in the form of repeated emesis and regurgitant vomiting (see Fig. 147). With obstructions well along within the gastrointestinal tract, as the voluminous coils of bowel above the blockage undergo distention, the abdomen as a whole also becomes progressively distended. Reference has already been made to the occasional occurrence of visible ladder patterns from distended small intestinal loops, to the peripheral or horseshoe shaped distention of the abdomen from obstructions in the sigmoid colon or rectum, and to the enormous, generalized, and ever increasing enlargement of the abdomen consequent upon bowel stasis due to paralytic ileus (adynamic intestinal obstruction). The colicky pain, as noted, represents the effort of the intestinal musculature to drive the contents of the bowel lumen beyond the constriction. With abrupt cessation, then, of the processes of alimentation the four most important symptoms are:

- (1) colicky pain
- (2) regurgitant vomiting
- (3) absolute constipation and
- (4) steadily increasing distention.

While as will be observed in a consideration of individual types of intestinal obstruction there are instances in which one or more of these cardinal symptoms may be slight in severity or even absent (little or no pain with carcinomatous obstruction; lesser degree of emesis with low obstructions; diarrhea rather than constipation with intussusception; little

generalized distention with very high obstructions) these are nevertheless the outstanding guides in the immediate history which point to the diagnosis of obstruction. And it has been stated as a clinical rule: "If a patient suffering from a sudden attack of abdominal pain has constantly recurring vomiting and every effort to secure the passage of feces or flatus results negatively, a diagnosis of intestinal obstruction may be made."<sup>191</sup>

Other symptoms and systemic signs observed with obstructions have to do largely with the underlying causative lesions such as cancer (cachexia); with the dehydration (thirst, dyspnea); with the excessive stimulation of afferent nerves (shock, rapid pulse); with the toxemia (urinary changes, leucopenia, coated tongue); and with complications such as peritonitis (pulse, temperature, leucocytosis). The late picture with obstruction is as hopeless as it is typical and an early diagnosis, the *sine qua non* of success in treatment, must rest in great measure upon the prompt recognition and proper evaluation of the four chief symptoms enumerated.

Fortunately for positive diagnosis, about half of all obstructions of intestines occur outside the abdomen, within hernial orifices.<sup>192</sup> (See Chart 1.) Here careful physical examinations should reveal the seat of the trouble (Fig. 149). And since all other causes combined scarcely equal in frequency this single cause, painstaking examination of the sites at which herniae occur becomes an imperative necessity whenever bowel stoppage is in the least degree suspected. How often do cases come under observation in which a patient is suffering from pain, vomiting, constipation, or distention and in which no diagnosis has been made, yet in which hernial rings, particularly the femoral, have had no examination! The incidence of hernial strangulation or obstruction among etiological factors does not warrant neglect of this particular routine of inspecting and palpating all sites for rupture. The physical test of next importance is rectal examination. This may reveal rectal cancer; fibrous, syphilitic or tuberculous stricture; sigmoid volvulus;

Palpating Hernial  
Rings and Rectum



FIG. 149. (From Babcock's Text Book of Surgery, W. B. Saunders & Co.)

A. Strangulated femoral hernia. The sac has been opened, blood-stained fluid has escaped, the strangulated loop of ileum, although dark red or nearly black, is shiny, resilient, and viable.

B. Strangulated loop of bowel from hernial sac showing constriction from pressure at the hernial ring, the gut is viable. A strangulated loop should always be pulled well out of the wound to make sure that the constriction at the abdominal ring has not produced necrosis. Bowel reduced with radical herniorrhaphy without drainage.

C. A strangulated loop of bowel withdrawn from hernial sac showing grooves from pressure necrosis. Resection of intestine, enterostomy, or the formation of an artificial anus is necessary.

or colic intussusception. Since rectal cancer is the most common cause of chronic intestinal obstructions (and of acute engrafted upon chronic) and 96 per cent of rectal cancers<sup>193</sup> are within reach of the examining finger, it is clear that rectal digital examination combined with palpation of hernial orifices may be looked to as a means for establishing a positive diagnosis in the majority of instances of intestinal obstruction.

Additional  
Physical Findings

Physical examination may reveal other evidence. Tumors are sometimes felt or seen. With acute obstructions intra-abdominal tumors are found in but 16 per cent of cases although with chronic obstructions the incidence of masses rises to 54 per cent.<sup>194</sup> Often the mass is a malignancy, the commonest location being retrosigmoid, next cecum or ileocecal junction, then other parts of large bowel, and least often, small bowel. Diffuse tympanytic masses are caused, though rarely, by volvulus (ileojejunal or sigmoid) or occur in conjunction with an internal hernia (into lesser sac; paracecal or paraduodenal fossa). The tumor subject to easiest identification is the sausage-shaped mass of intussusception. Characteristic distentions have been mentioned (central with small bowel blockage; in flanks with large gut stoppage; local with volvulus and internal herniae; diffuse and massive with adynamic ileus). Ladder patterns and visible peristaltic waves which pass regularly to a fixed point and there abruptly terminate have been noted. Inspection may also reveal scars of old operations which suggest underlying band obstruction; while the rare observation of stigmata of congenital defects (high palatine arch; cleft palate; hare lip; polydactylism) brings to mind the possibility of a persistent omphalomesenteric duct (Meckel's diverticulum). Auscultation, it has been stated, at times reveals excessive gurgling and splashing sounds with acute mechanical obstructions and a deadness or silence with adynamic and spastic ileus. Percussion yields little information of value.<sup>194</sup> Rigidity is usually absent with early obstruction or may involve so small a segment of belly wall, be so moderate in degree, or prove so difficult to differentiate from the voluntary

rigidity due to pain and efforts with vomiting that its usefulness in diagnosis is not great. Sensory disturbances, also, prove of but little value since scarcely ever is an identical segment of bowel trapped or blocked in consecutive cases. And local tenderness is sometimes present and sometimes absent; in the former instances it is hard to distinguish from that due to peritonitis. Indeed peritonitis is often associated; for peritonitis may lead to intestinal obstruction (adynamic type) and obstructions (mechanical variety) lead to peritonitis. Systemic examinations usually reveal little which is typical of intestinal obstruction alone. In general, the slight value of the physical examination, or its absolute lack of any clear cut value in a considerable group of cases forms a sharp contrast to its positive worth when a strangulated hernia, a rectal neoplasm, or a sausage shaped tumor is discovered.

Etiological Classifications

The true clinician, when attempting a diagnosis, bears continually in mind a classification of causes and he is acquainted with the law of chance or the probabilities regarding these causes; he is guided by established clinical rules. The knowledge, for example, that herniae dominate other etiological factors in obstruction puts him on guard relative to this dangerous condition, for every hernia may be considered as a potential intestinal obstruction; and to know that there are among the long list of possible causes but three other *common* types, each of which is quite rigidly restricted to a certain age group, increases his accuracy in preoperative diagnosis as nothing could do but a statistical study of known operative findings.

For a study of any specific case of suspected intestinal obstruction the following classification of possible causes is serviceable (see Figs. 150 and 152):

## A. ACUTE OBSTRUCTIONS

### I. MECHANICAL TYPES

- a. External hernia (inguinal, femoral, umbilical, incisional, etc.).

- b. Adhesions or bands (previous peritonitis; sites of operations).
- c. Intussusceptions (ileal, ileocolic, colic).
- d. Carcinomata and other neoplasms (chiefly in rectum or sigmoid).
- e. to i. Volvulus (sigmoid, jejunoileal).
  - Internal herniae (lesser sac; diaphragm; fossae, etc.).
  - Duodenomesenteric ileus (postoperative; with viscerop-  
tosis).
  - Meckel's diverticulum.
  - Obstipations (impacted gallstones; enteroliths).

## 2. NON-MECHANICAL TYPES

- a. Adynamic or paralytic (usual cause, peritonitis).
- b. Dynamic or spastic (reflex from blow) (seldom surgical).
- c. Combinations of spastic and paralytic (as with thrombosis of embolism of mesenteric vessels).

## B. CHRONIC OBSTRUCTIONS

Newgrowths  
 Strictures  
 Adhesions  
 Impactions  
 Hirschsprung's Disease

Of mechanical types, generally speaking, herniae cause half of cases, and there are but three other *common* forms, namely, (1) intussusceptions (over 75 per cent of which occur during the first two years of life), (2), cancers (occurring usually in middle or late life) and (3) peritoneal bands and adhesions (affecting any who have had peritonitis or abdominal operations).<sup>192</sup> (See Chart I.) All other varieties of mechanical obstructions combined (internal herniae, diverticula, impacted stones, volvulus, mesenteric thrombosis, etc.) account for but from 15 per cent to 20 per cent of instances.<sup>195</sup>

To memorize causes of obstruction upon a purely anatomical basis as (a) those affecting bowel lumen (impactions;

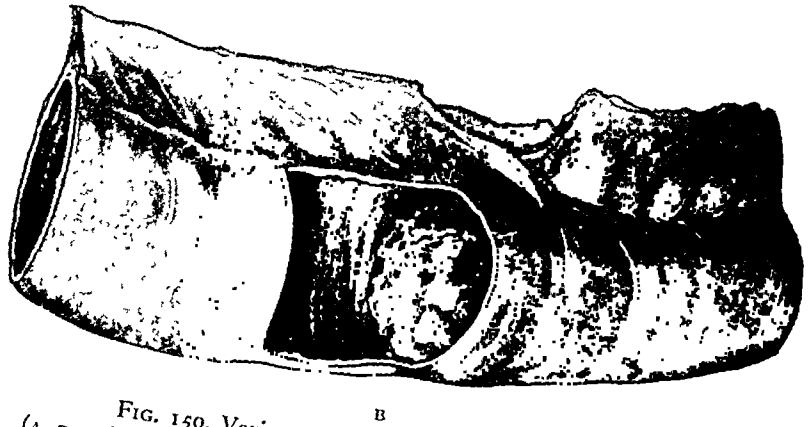
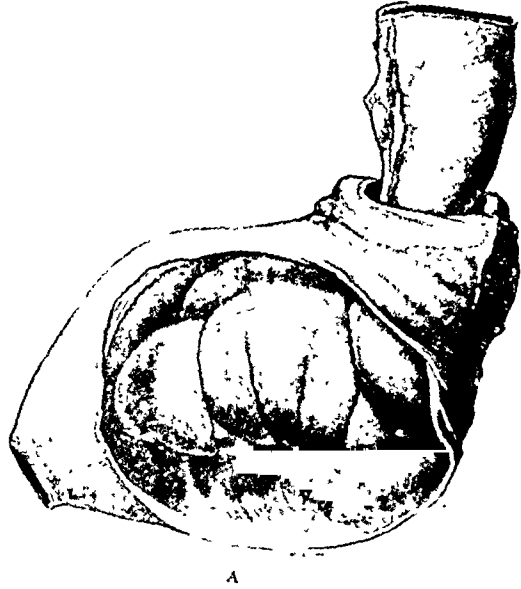
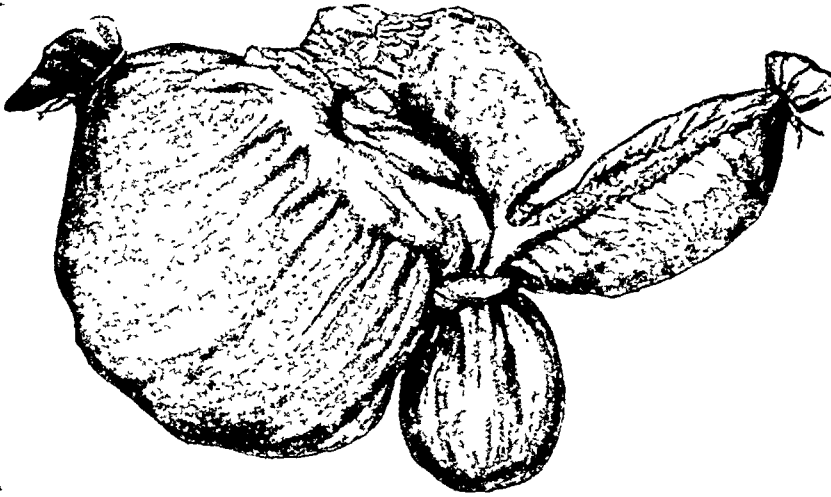
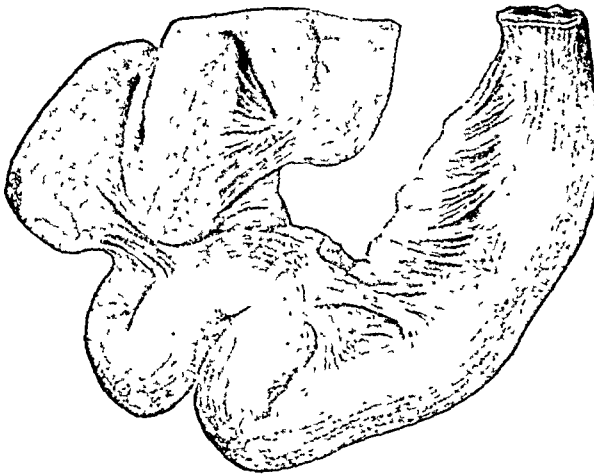


FIG. 150. Various forms of intestinal obstruction.  
 (A, B and C From Walton's Surgical Diagnosis, Wm. Wood & Co.)  
 A. Acute intussusception.  
 B. Acute intestinal obstruction from a gallstone.



C



D

FIG. 150.

- c. Strangulation of intestine by a band.
- d. View of the cicatricial adhesions and bands of the convexity and mesenteric insertion of the agglutinated intestinal coils (Payr). (From Keen's Textbook of Surgery, W. B. Saunders & Co.)



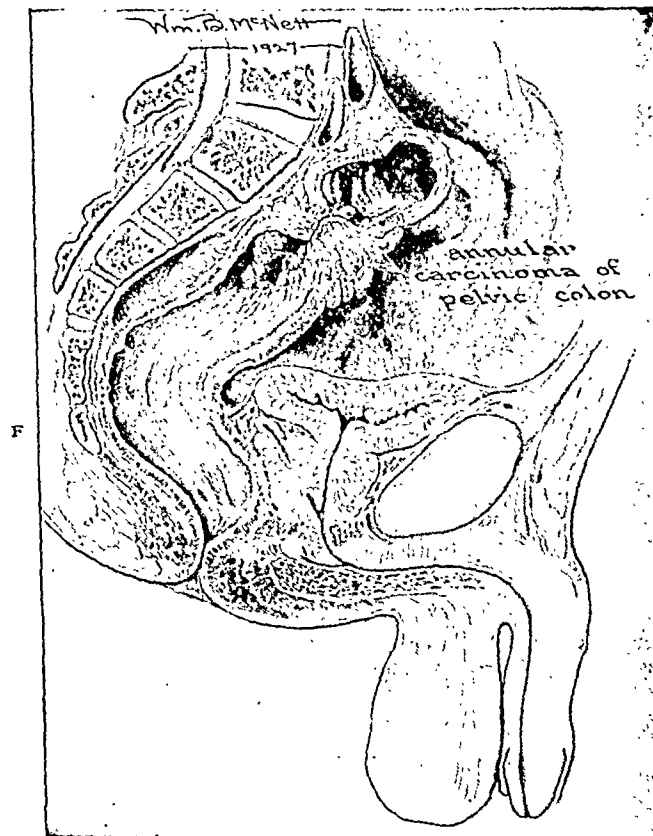


FIG. 150.

E. Hernia into the fossa duodeno-jejunalis (Treitz). The hernial orifice is displaced to near the cecum. The colon has been drawn aside to show the sac which contains all the small intestine. (From Treves' Manual of Operative Surgery, Lea & Febiger.)

F. Annular scirrhus carcinoma of the pelvic colon producing intestinal obstruction. (From Babcock's Textbook of Surgery, W. B. Saunders Co.)

polypoid or benign tumors, etc.) (b) those affecting bowel walls (cancers, strictures, Hirschsprung's disease, etc.) and (c) those affecting the intestine from outside (adhesions, bands, tumors, etc.) is of relatively little use for the clinician who must associate with a given cause an idea as to its likelihood of occurrence. Clinical rules like all generalizations serve as but rough guides and are not free from flaws; neither does it matter with the particular patient who actually has one of the more rare forms of obstruction that the majority of other patients have some other single cause; and general rules are by no means substitutes for painstaking historical and physical examinations; but the proved laws of chance are invaluable in indicating the likely clinical diagnosis, and they ensure that the trained clinician approach the individual case in a manner which is systematic with regard to what previous experience with intestinal obstruction has taught. Restating, then, and regrouping in various ways clinical rules concerning acute intestinal obstruction:

**Clinical Rules and  
the Laws of  
Chance**

With all patients except infants the possibility of a hernial obstruction or strangulation should be the first thought.

The most common surgical emergency in infancy (under two years) is intussusception.

Given an infant with evidences of intestinal obstruction, the likely causes, in order of frequency, are intussusception, hernial obstruction, and blockage from some congenital defect such as a persistent Meckel's diverticulum; but of all causes intussusception greatly predominates.

The most commonly overlooked physical evidence of an intestinal obstruction is an incarceration or strangulation of a femoral hernia.

A history of a previous attack of appendicitis, salpingitis, cholecystitis, or some other peritoneal inflammation gives a suggestive lead as to the site of a subsequent intestinal obstruction.

A history of preceding common duct obstruction brings to mind the possibility of obturation from a gallstone; a history of

syphilis suggests a gummatous infiltration or stricture; a history of tuberculosis indicates the chance of a tuberculous enteritis with ulceration or stricture formation or of a *tabes mesenterica* with pressure on the bowel from without.

With a viscerotomic individual volvulus is more likely than with the normal.

Evidences of heart disease or aortitis or of embolic phenomena elsewhere point toward plugging of the superior mesenteric artery.

Obstruction occurring in the presence of acute peritonitis is most likely to be adynamic in type.

With the aged after herniae, malignancies of the large bowel are to be thought of and a rectal examination is always indicated.

Although the operative mortality with strangulated herniae is lower than that with most forms of operations for acute obstruction strangulated hernia still is the most common cause of death with acute obstruction.

High intestinal obstruction occurring immediately after a laparotomy is likely due to duodenomesenteric ileus; obstructions occurring in those who have undergone intra-abdominal operations are often caused by peritoneal band or adhesions.

When on physical examination no hernial, rectal, or abdominal mass is found, and when the patient has had neither peritonitis nor an intraperitoneal operation one of the rarer forms of obstruction is to be considered.

With definite evidence of acute intestinal obstruction when a diagnosis of the cause cannot be established from a careful historical and physical examination, immediate operation to attempt the diagnosis by intra-abdominal exploration is definitely indicated, for treatment must be prompt if the life is to be saved.

#### Summary

To summarize and to repeat for emphasis salient points regarding the clinical diagnosis of intestinal obstruction:

Two questions must be answered; (1) has an obstruction occurred? and (2) what is the probable nature and site of the

obstruction? To answer the first question chief reliance is placed upon history. If pain, vomiting, constipation, or abdominal distention are complained of, by cross examination seek to settle whether the pain is colicky, the vomiting regurgitant, the constipation absolute, or the distention steadily increasing (qualifying points of the utmost importance). Ascertain the exact site or sites to which pain is referred. Give special attention to previous operations or attacks of peritonitis (appendicitis; salpingitis, etc.); also to a history of hernia, syphilis, tuberculosis, marked loss of weight, common duct obstruction; study with great care an account of the expulsive activities of the alimentary tract (increasing constipation, constipation alternating with diarrhea, blood, mucus, tenesmus, ribboning of stools). Examine all hernial orifices and the rectum. Search carefully for intra-abdominal masses. Recall that a totally negative local or systemic examination does not necessarily rule out obstruction. When the history or the examination points to the presence of a bowel stoppage keep in mind the laws of probability in reaching a clinical opinion as to the likely site.

Refinements as to diagnosis need not be carried too far. Early diagnosis as to the blockage itself is the most important matter. Time spent in prolonged laboratory tests with this unusually serious condition, or in extended efforts by means of repeated enemata to prove the presence of absolute constipation, is frequently time taken at the expense of the patient's life expectancy. With acute obstructions treatment by operations must be prompt for each hour adds to the risk. Perhaps in no other surgical emergency is procrastination more disastrous and the necessity for a serious attempt at an immediate diagnosis upon the basis of information at hand at the first examination more pressing. There are but few instances of acute intestinal obstruction in which the underlying condition can not be relieved or the condition of the patient alleviated if operation is undertaken within the first twenty-four hours of onset of the acute symptoms.<sup>196</sup>

Early Diagnosis  
and Prompt  
Operation

**Mortality with  
Obstruction**

The mortality with acute intestinal obstruction is out of all proportion to that from any other common surgical affection of the gastrointestinal tract. Until recently, considering all causes of obstruction together, with the most approved methods of treatment more patients died than recovered (an immediate mortality of over 50 per cent). And even a few most recent statistical studies show a mortality rate after operations, grouping all types of obstructions with the exception of hernial strangulations, which ranges from fifty to 80 per cent<sup>197</sup> and without prompt relief bowel stoppage, once complete, tends to be uniformly fatal. Spontaneous recovery from mechanical blockage is so rare an occurrence that it can scarcely be looked for. There is one type of obstruction which responds with almost certainty to non-surgical treatment, namely duodenomesenteric ileus (see page 218); and intussusception has been dealt with in some instances by means of external manipulations.<sup>198</sup> But with these exceptions there is fair agreement that operative intervention represents the only reasonable chance for recovery. By comparison with results now obtained from operations for other serious abdominal diseases the mortality rate with obstruction still is appalling and constitutes a challenge to concentrated surgical research and study. It has been stressed that the chief factor in obtaining improved results is early diagnosis followed by prompt operation. And as this doctrine has gained in acceptance the general mortality rate has been correspondingly lowered. The most encouraging statistics available record an immediate death rate of but 16 per cent when operations were performed within twenty-four hours of onset of acute symptoms, (and among cases in this list were several with thrombosis of mesenteric vessels) and of but 30 per cent with operations performed at varying periods after onset.<sup>199</sup> An appended chart reviewing over 3000 cases demonstrates a mortality rate, which may still be considered as unusually low, of less than 20 per cent for hernial obstructions and 35 per cent for remaining grouped cases, (see Chart 1).

CHART I  
ANALYSIS OF 3064 CASES OF INTESTINAL OBSTRUCTION (SOUTTAR)

Cause	Site				Operation					Result	
	Small Int.	Right Colon	Left Colon	Rect.	Reduction	Enterotomy	Enterostomy	Anastomosis	Resection	R.	D.
Gall stones.....	26	...	2	..	...	25	3	..	..	14	14
Carcinoma.....	2	46	246	54	...	..	313	48	37	202	156
Adhesions.....	308	23	10	2	283	..	..	36	20	235	107
Internal strangulation...	211	6	6	..	134	..	27	32	33	149	74
Intussusception (idiopathic)	526	100	14	..	544	2	13	48	58	476	137
Intussusception with tumor	39	18	20	..	47	3	17	12	18	36	38
Total (excluding hernias).	1655										
Omental											
Inguinal hernia.....	457	31	13	29	501	2	11	27	34	451	83
Femoral hernia.....	537	5	4	29	618	1	14	55	57	557	118
Umbilical hernia.....	159	36		12	170	1	14	27	33	129	71
Total hernias.....	1409										
Grand total.....	3064										

A routine for intra-abdominal exploration might be summarized thus; open the peritoneal cavity near the site of a hernia, old operative scar, local mass, or other quite certain site; otherwise employ a right midrectus incision which may later be elongated in either direction. Before handling anything gain all possible information by inspection (look for gangrenous or discolored gut, for greatly enlarged loops, for stringy bowel). Search for the site of obstruction in one of three ways; (a) allow a loop of intestine to present into the wound; note which end presents most easily and quickly and which slowly and with more difficulty, (the latter probably leads toward the obstruction); (b) if stringy or collapsed bowel is observed follow it orad to find the site of constriction (see p. 350); (c) if greatly dilated and discolored loops are found the site of obstruction is probably where the distention and discoloration are greatest. Examine all hernial rings, both external and internal (inguinal, femoral, umbilical, foramen of Winslow, fossa of Treitz, paracecal and parasigmoid regions; diaphragm,

Intraperitoneal  
Exploration

etc.). Slip the examining hand to the left lower quadrant, especially where all loops both of small and large bowel seem enlarged and examine the iliac colon, pelvic colon and upper rectum. See that all loops of small bowel are free from the parietes and may be displaced en masse to the right and left on the mesenteric hinge. Trace the root of the mesentery, seeking mesenteric slits. Follow systematically foot after foot of bowel if need be, particularly the last 5 to 10 ft. of ileum if Meckel's diverticulum is to be excluded. When necessary, incise and drain distended bowel (see p. 309); after repairing the bowel opening, re-examine the peritoneal cavity for additional information made available by the collapsed condition of the intestine. Be persistent, find the cause or rule out an obstruction even with poor risk cases (overlooked gangrenous loops or tight constrictions spell quite certain death). With acute mechanical obstructions, only in desperate cases does it seem justifiable to blindly make a temporary stoma in a presenting loop and withdraw. Exercise the utmost gentleness, even when explorations are extensive, avoiding evisceration and needless handling of gut. Show respect for already damaged tissues.

#### Experimental Data

Experimental studies regarding acute obstruction have been unusually extensive and they hold promise of leading in the near future to materially improved end-results in clinical cases, for already methods have been devised for definitely prolonging the lives of the laboratory animals. But so technical are the problems involved and so conflicting the data, that adequately to review such work falls distinctly beyond the scope of this book. To make brief additional references, however, to the chief causes of death with acute obstructions and strangulations (a, the element of toxemia; b, the factors of dehydration and disturbance of the acid-base equilibrium) serves the dual purpose of bringing out further points regarding gastrointestinal physiology and of emphasizing essential practical details in treatment. Appended bibliography also indicates authoritative sources from which to obtain information relative to this subject.<sup>200</sup>

Death from intestinal obstruction originally was attributed to shock, extreme loss of fluids from the body and starvation. The fluid loss and the inability of replacement through natural channels are so obvious and impressive a factor with acute obstructions that these were long taken for granted as outstanding in determining the fatal issue. Deaths which occurred so promptly that vomiting had not begun were explained upon the basis of shock or nerve exhaustion from pain and the overwhelming of vital centers by a rapid and steady flow of afferent stimuli. Suspicion that these explanations were inadequate to account for all the facts was aroused by the demonstration that simple replacement of lost fluids with water fails to prolong life; and that treatment with water and alkalies, the latter to combat a supposed acidosis as judged to be present by the dry tongue and the typical odor to the breath after prolonged vomiting, definitely hastened, rather than retarded death. There tends to be present, it was shown, an alkalosis rather than an acidosis, the odor of the breath being caused by the presence of acetone and other ketotic acids (a ketosis) due to the incomplete combustion of fats with the starvation which followed the constant vomiting. Thus there is found present a high rather than a low  $\text{CO}_2$  combining power of the blood; and whereas glucose seems indicated, sodium bicarbonate and other alkalies are definitely contraindicated. Chemical tests of blood show, furthermore, a marked decrease in the chlorides; also a sharp rise in the non-protein nitrogen content, chiefly in the form of urea. The chloride decrease appears to be uniformly present with simple bowel obstruction and the surprising fact seems demonstrated that it does occur where there is no vomiting. With certain of the experimental strangulations of the bowel no loss of chlorides occurs. The rise in non-protein nitrogen, upon the other hand, is present both with strangulations and with simple obstructions, but with the latter it occurs only *after* the fall in blood chlorides while prevention of the chloride fall prevents nitrogenous changes and prolongs, or even saves the life of the animal. Retention by the kidneys



of the nitrogenous compounds, it has been shown, does not account for the increase in the blood and apparently there is an actual new creation of these end-products of protein decomposition in excessive amounts at some point in the body. Suspicion that with intestinal obstructions, especially when high in the tract, some specific toxin is present was aroused by the observation that when normal animals were injected with material taken from strangulated or obstructed loops of other animals they promptly died after exhibiting almost all evidences of having had intestinal obstruction. Other experiments have demonstrated that such toxic material is not absorbed by normal mucous membrane, for several hundred times a lethal dose may exist within bowel lumen, yet the animal remain well provided the mucosa is intact. Absorption quickly takes place, however, when the membrane is injured; and once the lethal dose has entered the circulation no treatment of the obstruction itself nor any known form of supportive or other treatment is capable of preventing death. The nature of the specific toxin (denied by some who believe that the intestinal contents even when taken from non-obstructed parts of the duodenum or jejunum may be shown to be toxic) remains unknown notwithstanding much study regarding it. As to the source of the toxic material the following have been suggested; the bowel mucosa, the pancreatic juice, intestinal bacteria, etc.; and as judged by its actions when injected into normal animals it has been considered a toxic proteose, a histamine, activated pancreatic fluid, a bacterial toxin, etc. Experimentation has clearly demonstrated that symptoms begin earlier and death occurs more promptly when the point of obstruction in the bowel is located immediately below the opening of the common bile duct and pancreatic duct; also that the severity of the condition bears an inverse relationship to the proximity of the point of obstruction to this greatest danger zone. And bowel strangulations, as might be expected, have been shown to yield a far more acute clinical picture and to cause much more rapid death than do simple obstructions

to intestinal lumen without concomitant damage to the circulation.

This tremendous amount of investigation and the many theories regarding the toxic element with obstruction have not yet resulted in the discovery of any practical means for preventing death in clinical cases. At present there are available no confirmed statistics which demonstrate convincingly the value in reducing mortality of any method of treatment for acute and complete mechanical obstructions other than early surgical intervention. Limited figures with reference to the use of B. Welchii antitoxin are encouraging.<sup>201</sup> And the use of sodium chloride seems, upon experimental grounds and from early clinical enthusiasm, to be gaining a position as an established addition to therapeutic measures;<sup>202</sup> yet too few observations concerning its clinical use are available to form the basis for fair conclusions regarding its effect upon the death rate. It has been proposed that tests of the blood chlorides afford an index to the degree of the toxemia present for certain experiments suggest that the depletion of chlorides precedes protein destruction with the subsequent rise in the non-protein elements in the blood. The wisdom of repeated gastric lavage appears firmly established both upon experimental and clinical grounds; not only are toxic substances thus removed but in addition intraluminary pressure is relieved and further damage to mucosa presumably diminished or prevented, which is an important matter in view of the knowledge that excessive pressure within the bowel, as is that without, is capable of damaging the capillary blood supply to the lining membrane of the bowel with a secondary increase in the absorption of toxic products contained within.<sup>203</sup> Gentleness in handling obstructed loops seems also essential in view of the fact that toxic absorption only takes place after the bowel walls have been damaged. The general results from the use of stomata connecting bowel wall with the body surface have been disappointing and it has been pointed out that bowel motility is needed to force the contents to the stoma after one has been created,

Practical Suggestions

Sodium Chloride with Obstructions

whereas with most cases of obstruction motility has either been lost or greatly impaired by the time of operation.

**Sudden Toxic  
Absorption**

At times death occurs suddenly during the course of an operation for the relief of a strangulation and the frequency of this accident immediately after the bowel has been liberated indicates the possibility that there has followed as a result of the liberation of gut, a sudden absorption into the circulation of a lethal dose of the highly toxic contents of the previously strangulated loop. Accordingly it might be advantageous before the loop is liberated, especially when the case is one of long standing, first to aspirate the loop contents.

Concerning the treatment of acute intestinal obstruction the following generalization might be made: Since all of the physiological and chemical changes noted with the condition (vomiting, dehydration, toxemia, disturbance of acid-base balance) are secondary in nature, the first consideration, now as always is the immediate surgical relief of the bowel occlusion or strangulation itself.

**Intestinal  
Neoplasms**

Foregoing points relative to the diagnosis, management and experimental findings with acute obstruction illustrate the importance of gastrointestinal physiology to the clinician. It is upon his knowledge of physiology, also, and of the signs and symptoms of bowel obstruction that the clinician must largely rely in making a diagnosis, or suspected diagnosis, of an intestinal newgrowth when this is situated above the rectum. Only by this alertness to detect and adequately to investigate early and relatively trifling evidences of chronic or intermittent intestinal obstructions will small bowel and upper colic tumors be discovered, particularly when malignant, in time to effect a cure. These neoplasms often develop to an advanced stage before being discovered, since here, in contrast to the rectum, the bowel content is normally liquid or but semi-solid and the intestinal current so easily passes the growth that the processes of alimentation are but little interfered with.<sup>204</sup> Interference with function being slight, early symptoms tend also to be slight.

The evidences of chronic and intermittent obstructions vary from those of acute obstruction chiefly in degree. Colicky pain, even though mild and infrequent is the chief diagnostic

Chronic and Inter-  
mittent  
Obstructions

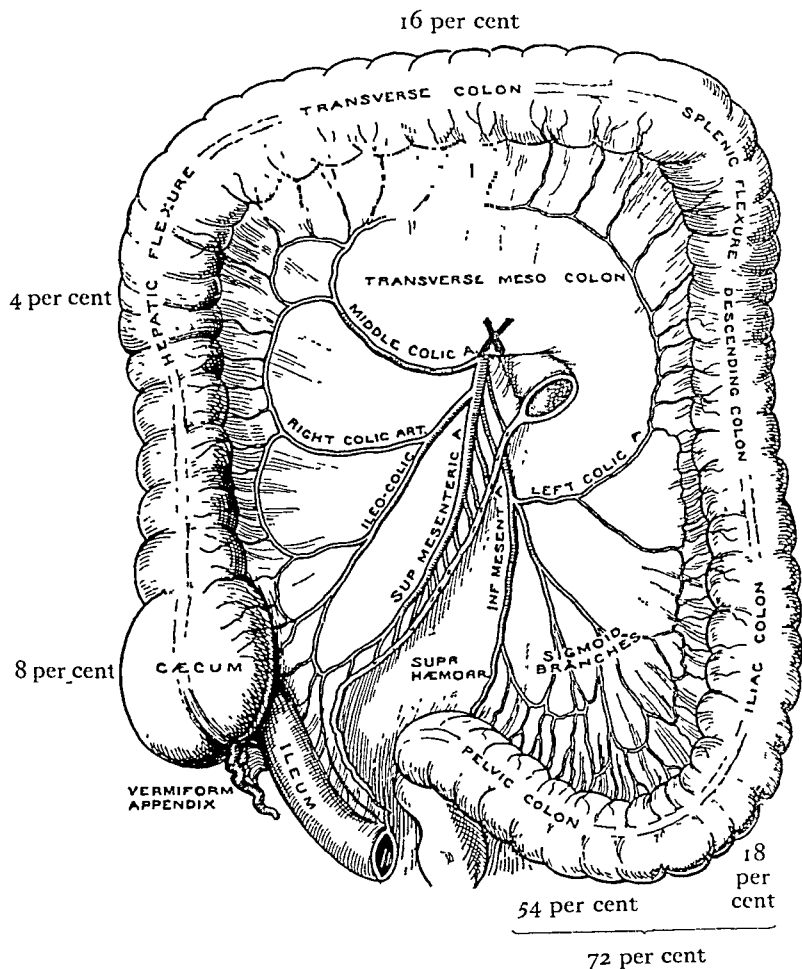
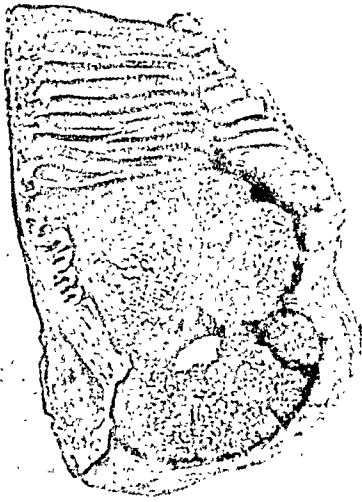


FIG. 151. Incidence of malignant neoplasms in various parts of large intestine. Figure based upon operative findings in 53 consecutive cases studied on the Third Surgical Division of Bellevue Hospital. (After Taylor's Operative Surgery.)

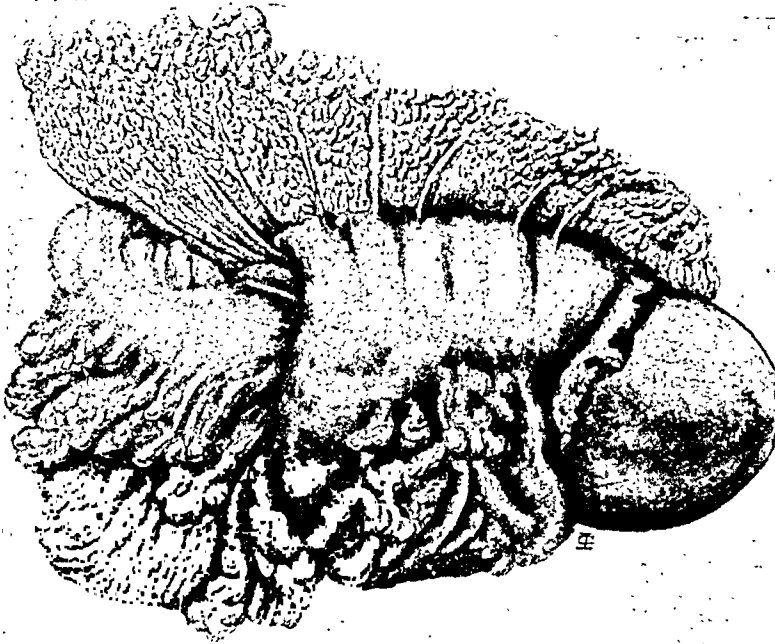
symptom; increasing constipation or constipation alternating with diarrhea is significant, as are also occasional attacks of vomiting. A point of great significance is the ever present anemia when the growth is malignant. This seems to be more profound the farther the growth from the rectum. And progressive anemia, slow loss of weight, a sense of vague abdominal



A



B



C

FIG. 152. Enteral neoplasms. Chronic intestinal obstructions. (From Walton's Surgical Diagnosis, Wm. Wood & Co.)

- A. Carcinoma of ileocecal valve.
- B. Sarcoma of small intestine.
- C. Chronic intussusception due to a lipoma.

[410]

discomfort (particularly when near the colic flexures or right lower quadrant) with or without evidence in the feces (occult blood, mucus, pus, cellular clusters) constitute an indication for radiographic studies, both by barium enemata and contrast meals. X-ray studies are best initiated by first giving the enema, since acute obstructions may be precipitated by the use of a heavy meal by mouth (Fig. 152).

Neoplastic enteropathies may be malignant or benign. Of malignant growths carcinomata are by far the most common; less frequently encountered are sarcomata and lymphosarcomata. Of benign tumors the common forms are adenomata (polyps) and lipomata; more rare types are fibromata, myomata, angiomata, and gaseous cysts.<sup>205</sup> An accompanying chart illustrates the incidence of these growths at various parts of the intestinal canal (Fig. 151 and Chart 1). As will be noted, rectal and sigmoid tumors far outnumber other intestinal growths. But for the diagnosis of these, rectal digital and sigmoidoscopic examinations almost always suffice. And since these neoplasms involve peripheral nerves and lie close to the anus the diagnosis tends to be more promptly established; for among factors calling attention to these masses are perineal, sacral and lumbar pains; mucous, pus and blood by rectum; tenesmus and a sense of unfinished defecation. Such secretomotor reflexes and referred pains are by no means so common with intestinal tumors situated elsewhere.

Unfortunately for end-results a palpable mass is already present in nearly half of the instances of high enteral growths by the time the patients seek advice. Masses at the colic flexures often prove difficult to detect and are always hard to identify since they are quite fixed and lie near viscera which are themselves not infrequently the seat of tumefactions (liver, spleen, kidney). And with neoplastic masses in the right lower quadrant differentiations from periappendiceal inflammatory masses or ileocecal tuberculosis may prove impossible by physical signs alone. Small bowel tumors usually display great mobility in all directions in contrast to relatively fixed

Types of Enteral  
Growths

Intestinal Masses

pancreatic growths; to biliary and cholecystic tumor which if movable swing upon an arc centered in the right upper quadrant; to splenic, nephritic and pelvic growths with which



FIG. 153. Rigid contraction of bowel from obstruction of small intestine by a fibrosarcoma. (From Quervain's Surgical Diagnosis.)

characteristic limitations of motion suggest respective points of origin; and with mesenteric growths which move most freely from side to side upon the mesenteric hinge but little or not at all in the upward and downward direction. Small bowel tumors are as the rule not larger than a hen's egg although at times, in spite of the normal fluidity of bowel contents fecal accumulations occur proximal to the growths (Fig. 153). Fecal impactions without tumors are exceedingly rare except within sigmoid colon or rectum, and the presence of a mass having the size and movability described, constitutes presumptive evidence of the presence of a newgrowth. While intestinal tumors are usually primary, the type of tissue making up the mass cannot be determined by local examination and even proves difficult on gross examination of the mass itself. It is to be borne in mind that malignancies of intestine occur at relatively early periods of life, nearly one-third occurring before the age of forty. And it bears repetition that because upper alimentary neoplasms remain so long clinically quiescent on account of the fluidity of the contents of the secretory and absorptive functional divisions of the tract, radiographic

studies should be promptly made whenever vague gastrointestinal symptoms, particularly those suggesting mild or chronic obstructions, are complained of. Early detection is all the more vital since neoplasms located within the small bowel are from the technical standpoint, most advantageously situated for complete removal.

The aim of the present chapter on physiological divisions of the gastrointestinal tract has been to stress in broad terms functional activities at various parts of the alimentary canal. With reference to operative surgery practical points were discussed regarding the creation and management of fistulae, stomata, and short circuits; stressing the necessity for keeping alimentation as nearly normal as consistent with pathological conditions. And concerning surgical diagnosis, functional activities were reviewed which serve to clarify common signs and symptoms of intra-abdominal disorders.

It is taken for granted that the surgeon would be less interested in a systematic resume of physiology as such (i.e. first to bowel motility; then of secretions; then of biliary and pancreatic functions, etc.). This he can readily find authoritatively given in physiological textbooks. But such resumes contain little or no references to surgical applications; and the problem for the clinician is one of correlation. They do contain, however, much that is controversial; and of controversies the surgeon finds quite enough within his own domain. The busy practitioner, whether right or wrong, is frequently impatient with needless details and with pure pedantry; he is even willing to remain somewhat uninformed as to theories; he seeks first and sometimes only, ideas which serve adequately to explain his problems, and aids which have been proved actually to *work*, for the benefit of his patients. In a word, the clinician evaluates physiology in terms of applicability.

Applied physiology, then, remains a keynote throughout succeeding pages. And the present introductory chapter, pointing out certain physiological aspects of surgical gastroenterology, indicates the method which will subsequently be

Applied Physiology



employed in dealing with topics to follow. The discussion of functional divisions of the alimentary tract, as here given, is to be considered incomplete and unfinished. For under the heading of vascular and lymphatic absorption, next to be reviewed, will be taken up the physiology of nutrition (enzymes, digestion, selective absorption of mucous membranes); and in the chapter on visceral neurology will be found the subjects of gastrointestinal motility and reflex actions (peristalsis; peristaltic rush; ileogastric reflex); while the physiology of the portal circulation and of bile production will be dealt with in a section devoted to a study of the liver; and similarly pancreatic physiology has been assigned separate space. In short, the discussion of functional processes within the gastrointestinal tract and its derivatives is so distributed as to ensure space in which adequately to deal with practical clinical applications.

#### QUESTIONNAIRE

1. What are the great functional divisions of the gastrointestinal tract? Give boundaries.
2. What are the three chief phases of alimentation?
3. What is meant by foregut derivatives; midgut derivatives; hindgut derivatives?
4. Name the point in the gastrointestinal tract which roughly separates the functional foregut from the functional midgut.
5. What is meant by the absorptive division of the alimentary tract? What division lies cephalad? What caudad? Roughly identify these divisions anatomically.
6. Why cannot the duodenum or transverse colon be considered as functional units?
7. What is the arterial blood supply of the various functional divisions of the gastrointestinal tract? Describe their nerve supplies.
8. To what degree do functional bowel divisions overlap?
9. What enzymes or digestive ferments are found in the gastric juice?
10. What substances are absorbed by the gastric mucosa?
11. What substances are absorbed by the mucous membrane of the rectum and pelvic colon?
12. To what extent does secretion occur within colon?
13. In the presence of bowel stasis how may the patient be nourished?
14. When was intravenous administration of fluids first employed?
15. How much small bowel may be resected without causing certain death?
16. What is the character of the discharge from a high jejunostomy?
17. What distressing signs and symptoms accompany high jejunostomies? How may these be controlled or alleviated?
18. How long should the surgeon wait for spontaneous closure of a high jejunostomy?
19. What are the digestive ferments or enzymes in the pancreatic juice? In the intestinal secretions?

20. Describe several ways for dealing with surface excoriations and tissue digestion as observed with high fistulae.
21. How may the surgeon tell whether a fistula which he sees for the first time is high or low in the gastrointestinal tract?
22. What foods should be avoided by patients with intestinal fistulae? Describe a satisfactory diet for a patient having an ileostomy.
23. What percentage of feces consists of undigested food and food residues?
24. What is a mucous fistula? A Thiery-Vella fistula? An appendiceal mucous fistula?
25. Is it safe to return a closed loop of bowel to the peritoneal cavity?
26. What is an intestinal short circuit? An occlusion of bowel? An exclusion of bowel? What is meant by an excluded segment?
27. What are the indications for performing short circuiting operations?
28. What are the indications for creating temporary intestinal stomata or fistulae? For permanent stomata?
29. What is an artificial anus? At what points in the bowel may artificial ani be created?
30. Why is it of advantage to create a preliminary or temporary stoma in the presence of an acute colic obstruction?
31. What are some of the precautions necessary in performing a colic resection?
32. What factors tend to prevent spontaneous closure of temporary fistulae?
33. Name some factors in the creation of temporary stomata which favor their early closure.
34. What are the three most common surgical diseases of bowel between duodenum and rectum?
35. Give a clinical classification of acute intestinal obstructions.
36. Classify intestinal obstruction according to etiology.
37. What are the chief causes of death with acute intestinal obstruction?
38. Why is a high intestinal obstruction more rapidly fatal than a low obstruction?
39. Why is the course usually more severe the closer the bowel obstruction to the ampulla of Vater?
40. Name some of the more common causes of "high" intestinal obstruction.
41. What is meant by regurgitant vomiting? Describe the condition.
42. Describe the vomiting with high intestinal obstruction; with low obstruction. Explain the differences.
43. How much fluid passes into the intestinal lumen through the mucous membrane within twenty-four hours? What becomes of this fluid?
44. What is fecal vomiting? Its frequency? Its significance?
45. Describe various types of pain caused by intestinal obstruction. Explain the differences.
46. What is an intestinal colic? Its cause?
47. What are some of the most common causes of umbilical pain? Of hypogastric pain?
48. What is meant by a metameric or segmental distribution of pain or of cutaneous tenderness?
49. What are the chief factors causing changes in the amount and character of pain with intestinal obstruction?
50. What are the chief signs and symptoms of acute intestinal obstruction? Name the four which are outstanding. Explain each.
51. What is meant by absolute constipation? How determined?
52. What percentage of acute intestinal obstructions are due to herniae?
53. What are the four most common types of acute intestinal obstructions? The approximate incidence of each?

54. What are the two most important tests in the physical examination for intestinal obstruction?
55. What is the most commonly overlooked physical evidence of acute intestinal obstructions?
56. What percentage of rectal neoplasms are palpable by rectum? What other causes of intestinal obstruction may be found by rectal digital examination?
57. Name some of the causes of tumefactions or tumors sometimes found upon physical examination for intestinal obstruction.
58. In approximately what percentage of cases of acute obstructions are tumors or palpable masses felt? How often in chronic obstructions?
59. What are the most common physical findings with intestinal obstructions?
60. Define and describe dynamic ileus; adynamic ileus; intussusception; volvulus; obstipation; duodenomesenteric ileus.
61. What is the most common surgical emergency in the first two years of life?
62. What are the most common causes of intestinal obstruction with the aged? In infancy? In middle life?
63. What type of intestinal obstruction causes most deaths? What types have the highest mortality rate?
64. What is the general mortality rate with acute intestinal obstructions?
65. What are some of the more important factors influencing the mortality rate with intestinal obstructions?
66. Describe the intra-abdominal examination with a case of acute intestinal obstruction of unknown origin.
67. Discuss the toxemia of high intestinal obstruction.
68. Discuss disturbances of the acid-base equilibrium observed with intestinal obstructions.
69. Discuss the administration of the following in the treatment of acute intestinal obstructions; glucose, sodium chloride, sodium bicarbonate, water, B. Welch anti-toxin.
70. What are the most characteristic chemical alterations in the blood with acute intestinal obstructions? Causes?
71. Discuss the advisability of gastric lavage with bowel obstruction.
72. Explain the sudden occurrence of death immediately following the liberation of a gangrenous segment of bowel.
73. What are the most common types of malignancies of intestine? The benign tumors?
74. Why are neoplasms of the right colon more difficult to detect than those situated upon the left side?
75. Name the evidences of chronic and of intermittent intestinal obstructions.
76. Give the relative percentages of incidence of newgrowths in various parts of the intestinal canal.
77. Name some common signs and symptoms of cancer of the rectum.
78. Name some common signs and symptoms of small bowel newgrowths.
79. How frequently are intestinal neoplasms palpable, (a) in the rectum and (b) in the small intestine?
80. Describe some of the characteristics (upon physical examination) of small bowel growths. Name other tumors with which they are most commonly confused. Give differential points.
81. Describe the more important laboratory tests in establishing a diagnosis of a malignancy of the intestinal tract.

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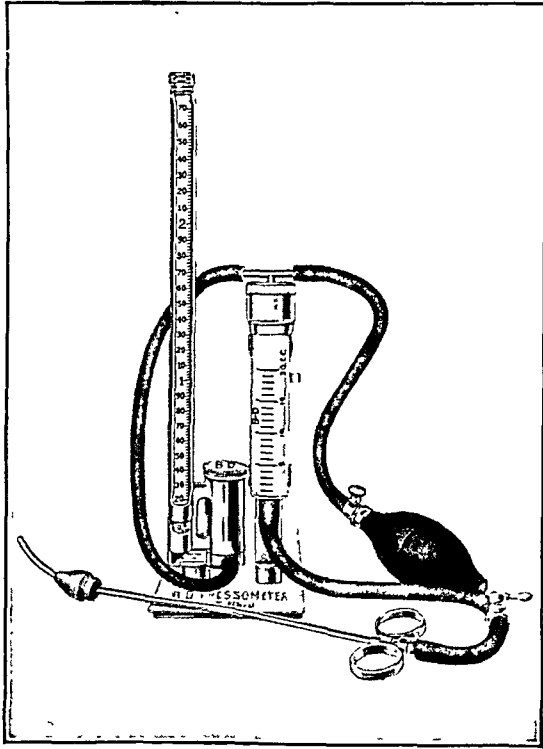


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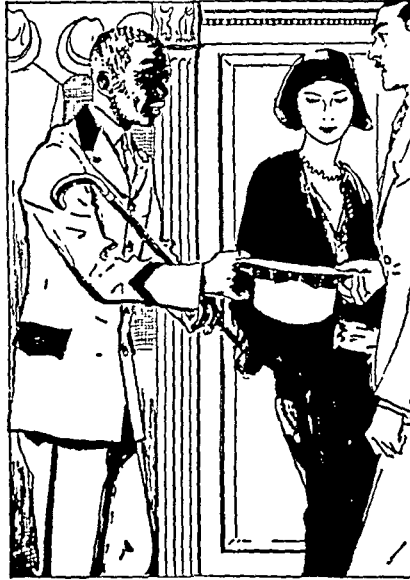
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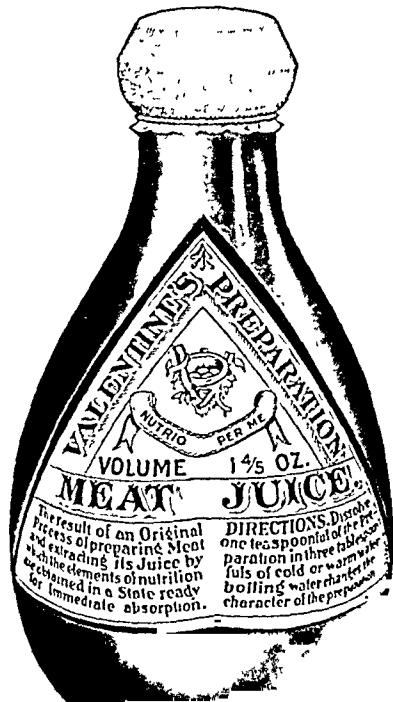
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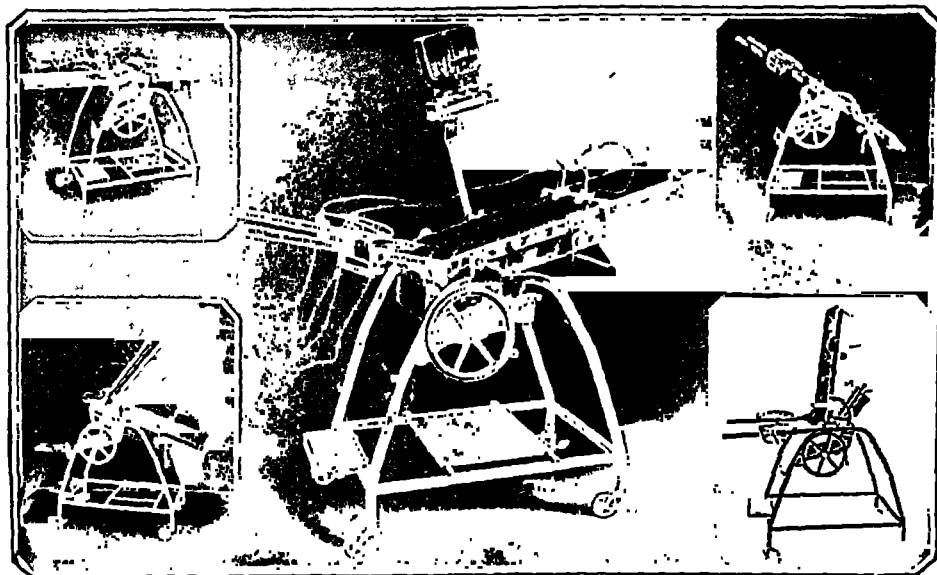
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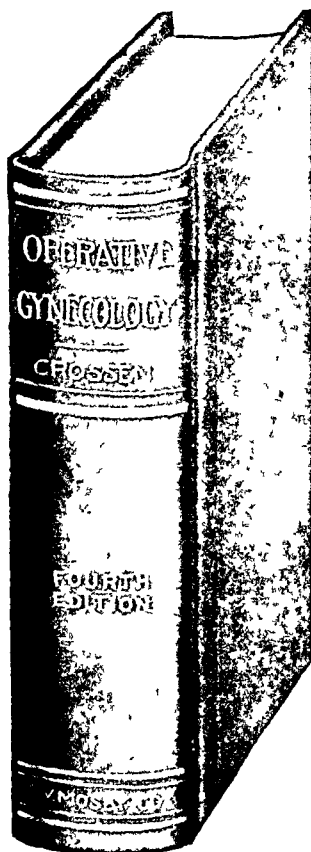
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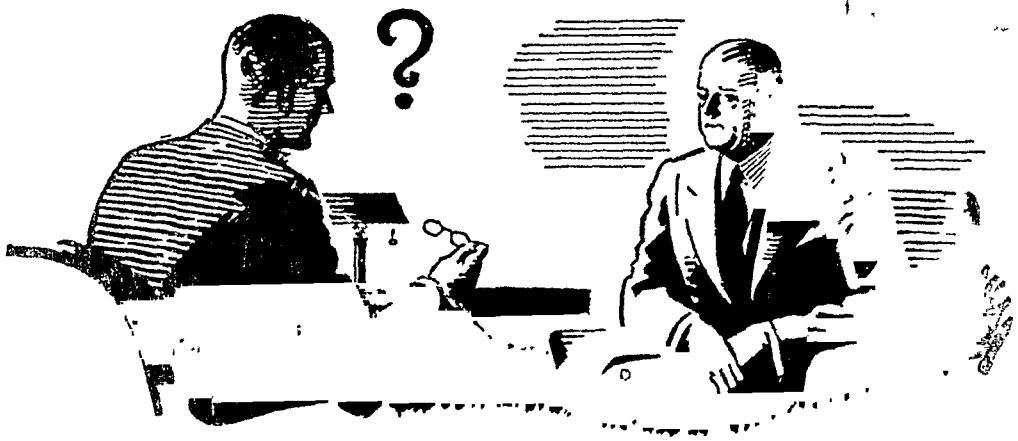
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